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IONOSPHERIC EFFECTS IN TEC DURING GEOMAGNETIC STORM SEQUENCE ON SEPTEMBER 9-14, 2005

Maxim V. Klimenko[*,†], Vladimir V. Klimenko[*] and Irina E. Zakharenkova[*]

[*] West Department of N.V. Pushkov IZMIRAN RAS
Kaliningrad, Russia
e-mail: maksim.klimenko@mail.ru
[†] Kaliningrad State Technical University
Kaliningrad, Russia

Key words: Geomagnetic Storm Sequence, Ionosphere, *TEC*, Solar Flares.

Summary: In the given study the calculation results of ionospheric effects in Total Electron Content (*TEC*) during geomagnetic storm sequence on September 9-14, 2005 with taken into account solar flares are considered. Under carrying out the calculation of the disturbed *TEC* values the model input parameters were set as function of *AE*- and *Kp*-index of geomagnetic activity according to different empirical models and morphological representations.

1 INTRODUCTION

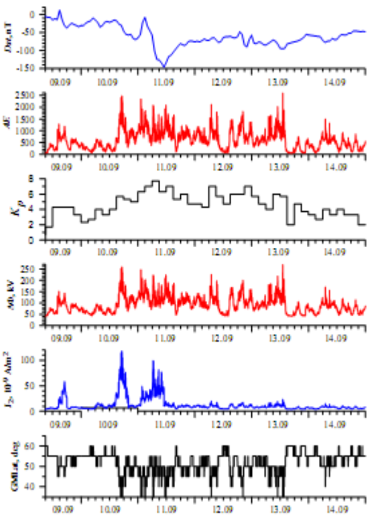

Figure 1: The behavior of *AE* and *Kp* indices of geomagnetic activity, potential drop through polar caps and amplitude and latitudinal location of field-aligned currents on September 9-14, 2005.

Many researches are devoted to numerical modeling of ionospheric storm effects[1-3]. They modeled: positive and negative effects of ionospheric storms, caused by thermospheric parameter changes; upper atmosphere heat balance on various phases of ionospheric storm; penetration of magnetospheric convection electric field to lower latitudes and disturbed ionospheric dynamo; external ionosphere and magnetosphere influence on the ionosphere *F*-region behavior during storms. It has been shown, that the basic formation mechanisms of ionospheric disturbances are the electric fields and thermospheric parameter variations. The given research is devoted to numerical modeling of ionospheric effects of storm sequence on September 9-14, 2005 with taken into account solar flares.

2 GEOMAGNETIC STORM SEQUENCE ON SEPTEMBER 9-14, 2005

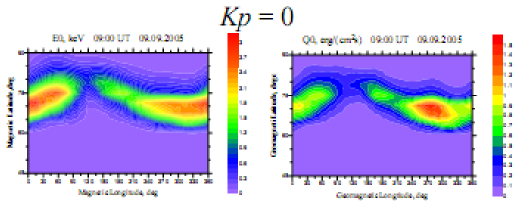

Figure 2: Particle precipitation energy and flux energy for *Kp*=0.

On September 9, 2005 the weak geomagnetic storm with the Storm Sudden Commencement (SSC) at 14.01 UT was observed. The same day there was a solar flare one of 10 most powerful solar flares registered for all history. Thus there was an emission coronal mass and the arisen shock wave has reached the Earth on September 10, 2005, having caused a weak geomagnetic storm with SSC near 06:00 UT which then was replaced by a strong magnetic storm with the SSC at 01:14 UT on September 11, 2005. This storm which proceeded down to September 15, 2005, has been caused by the second shock wave from the following solar flare. The storm has caused the strengthening of auroral activity, radio blackout and strong ionospheric storm. In the given study the ionospheric effects of sequence of geomagnetic storms on September 9-14, 2005 are considered. We carried out the calculation of ionospheric parameters during this geomagnetic storm sequence with taken into account five solar flares. In Fig. 1 the behavior of geomagnetic activity indices for the considered time period is shown.

3 INPUT PARAMETERS FOR MODEL CALCULATIONS

Calculation of ionospheric effects of storm seguence has been carried out with use of the Global Self-Consistent Model of the Thermosphere, Ionosphere and Protonosphere (GSM TIP) developed in WD IZMIRAN[4]. Only the $F_{10.7}$ changes from day to day were considered at simulation

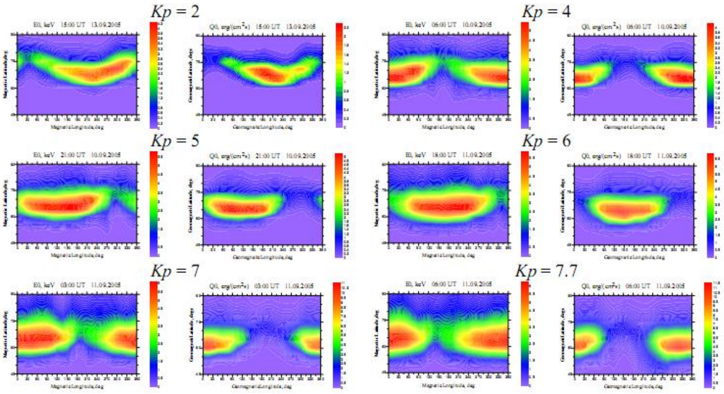

Figure 3: The same as in Fig. 2 for different *Kp*-index of geomagnetic activity.

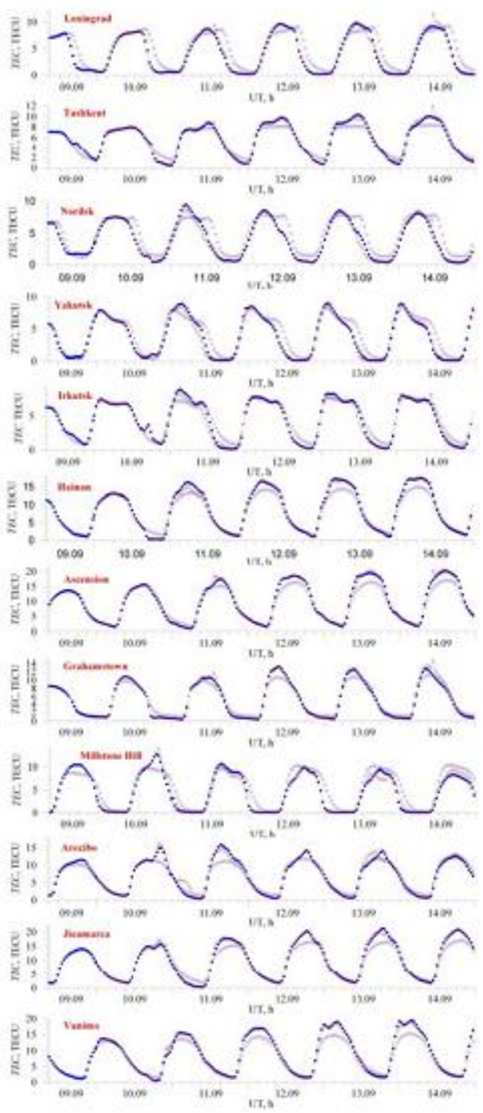

Figure 4: Calculated behavior of *TEC* above different stations. Quiet and storm time with and without taken in account solar flares (dotted, red and blue lines).

of ionospheric parameters in quiet geomagnetic conditions. At that the potential drop was set at geomagnetic latitude ±75º and field-aligned currents of second region at ±70º.

Earlier under carrying out the calculations of the disturbed ionospheric parameters the model input parameters were set as function of *Kp*-index of geomagnetic activity[5]. The analyses of obtained results show that the reasons of quantitative distinctions of calculation results and observations can be: the use of 3 hour *Kp*-index at the setting of time dependence of model input parameters; the dipole approach of geomagnetic field; the absence in model calculations the effects of the solar flares, which were taken place during the considered period. Now under carrying out the calculations of the disturbed ionospheric parameters the model input parameters were set as function of *AE*- and *Kp*-index of geomagnetic activity according to empirical models and morphological representations. Also, we taken into account the effects of solar flares. So, the potential drop through polar caps was set according to empirical formula[6], field-aligned currents of the second region were set according to experimental data[7,8] and particle precipitation energy and flux energy according to the model[9]. The shift of field-aligned currents of the second region to the lower latitudes was set as by[10]. At the SSC phase we set the 30 min. time delay of variations of the field-aligned currents of second region relative to the variations of the potential drop through polar caps[7,11]. In Fig. 1 the behavior of input parameters (potential drop through polar caps, amplitude and latitudinal location of field-aligned currents of second region) for the considered time period is shown. Fig. 2 and 3 shows the particle precipitation energy and flux energy for different *Kp*-index of geomagnetic activity obtained according to the model[9].

4 CALCULATION RESULTS AND DISCUSSION

In Fig. 4 it is shown the calculation results of total electron content (*TEC*) above different stations for 9-14 September 2005 with and without taken into account solar flares.

It is possible to see the disturbances caused by geomagnetic storms and solar flares. In Fig. 5 it is shown the comparison of model calculation results with experimental data of *TEC* behavior for a storm on September 10, 2005 above Millstone Hill[12]. It is visible that calculation results are in good qualitative agreement with experimental data.

In Fig. 6 it is shown the global maps of *TEC* disturbances obtained in calculations and observed by *GPS TEC*. It is visible that calculation results are in a good qualitative agreement with experimental data.

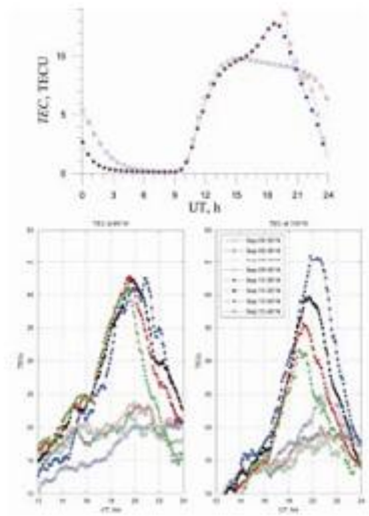

Figure 5: *TEC* behavior above Millstone Hill. Model calculation results (top), experimental data[12] (bottom)

5 CONCLUSIONS

- The using of the dependence of input parameters from *AE*-index with time resolution one minute allowed approaching the calculation results to experiment.
- The account of the solar flare ionospheric effects during storm sequence improved the description of *TEC* behavior.

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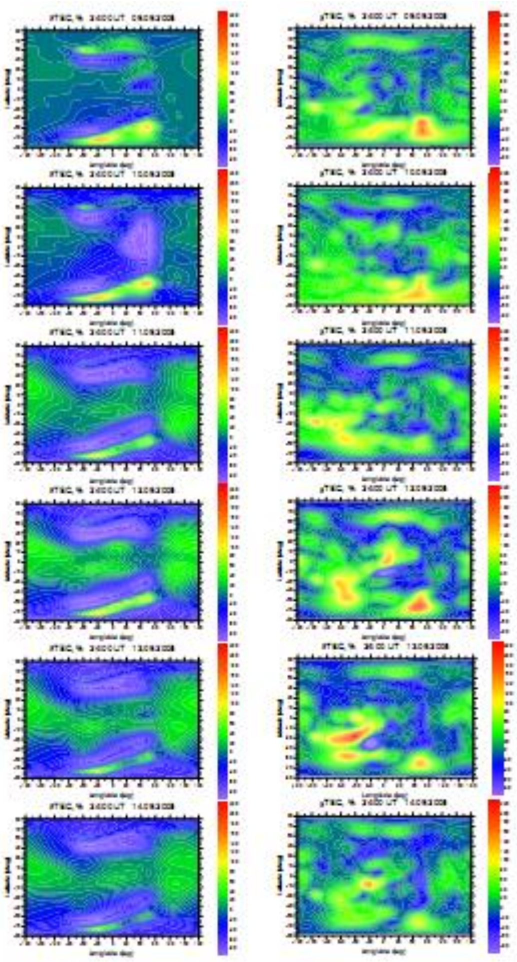

Figure 6: *TEC* deviations from background obtained in model calculations (left) and from GPS data (right).

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