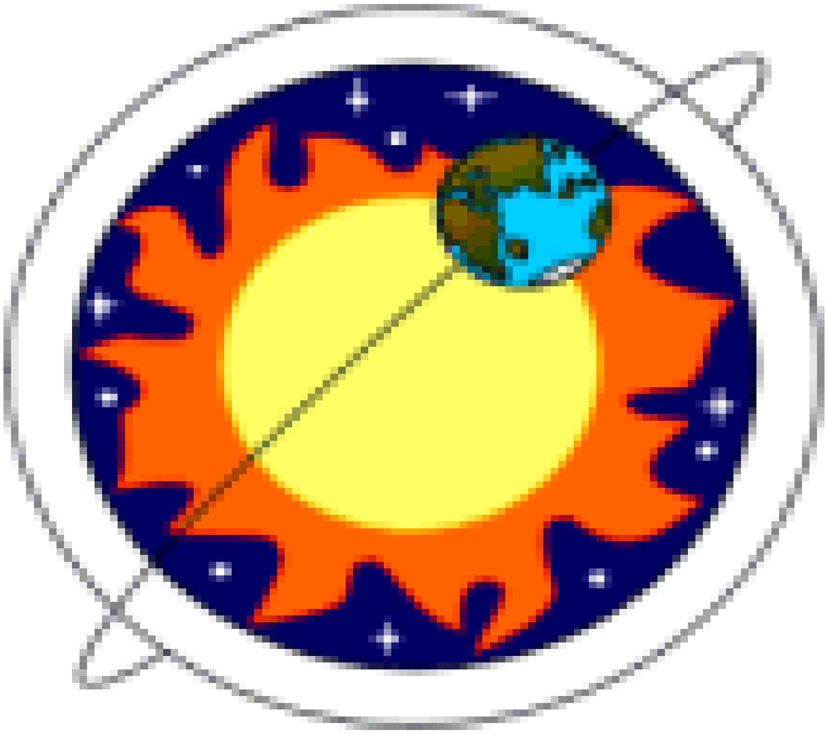

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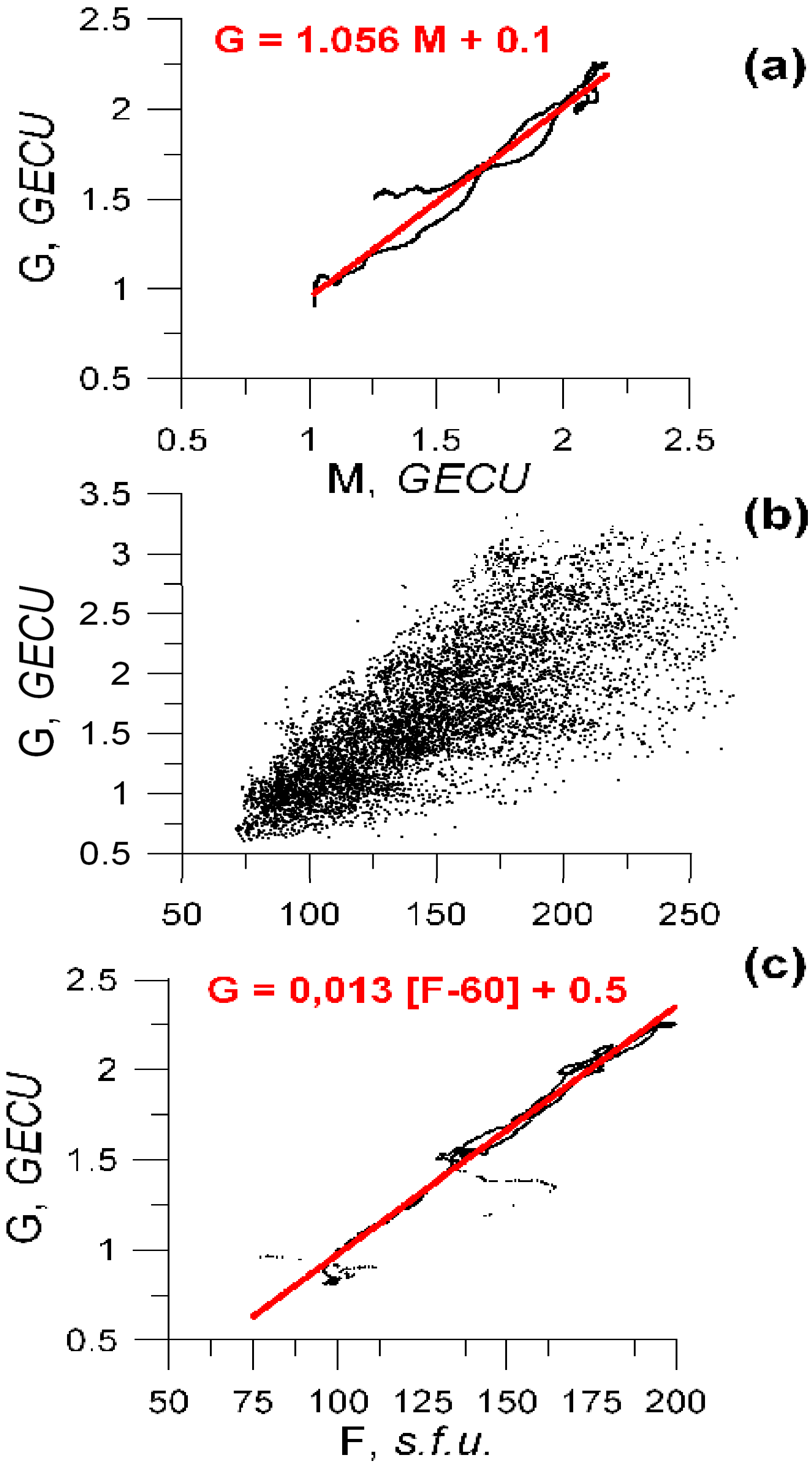
1. Introduction

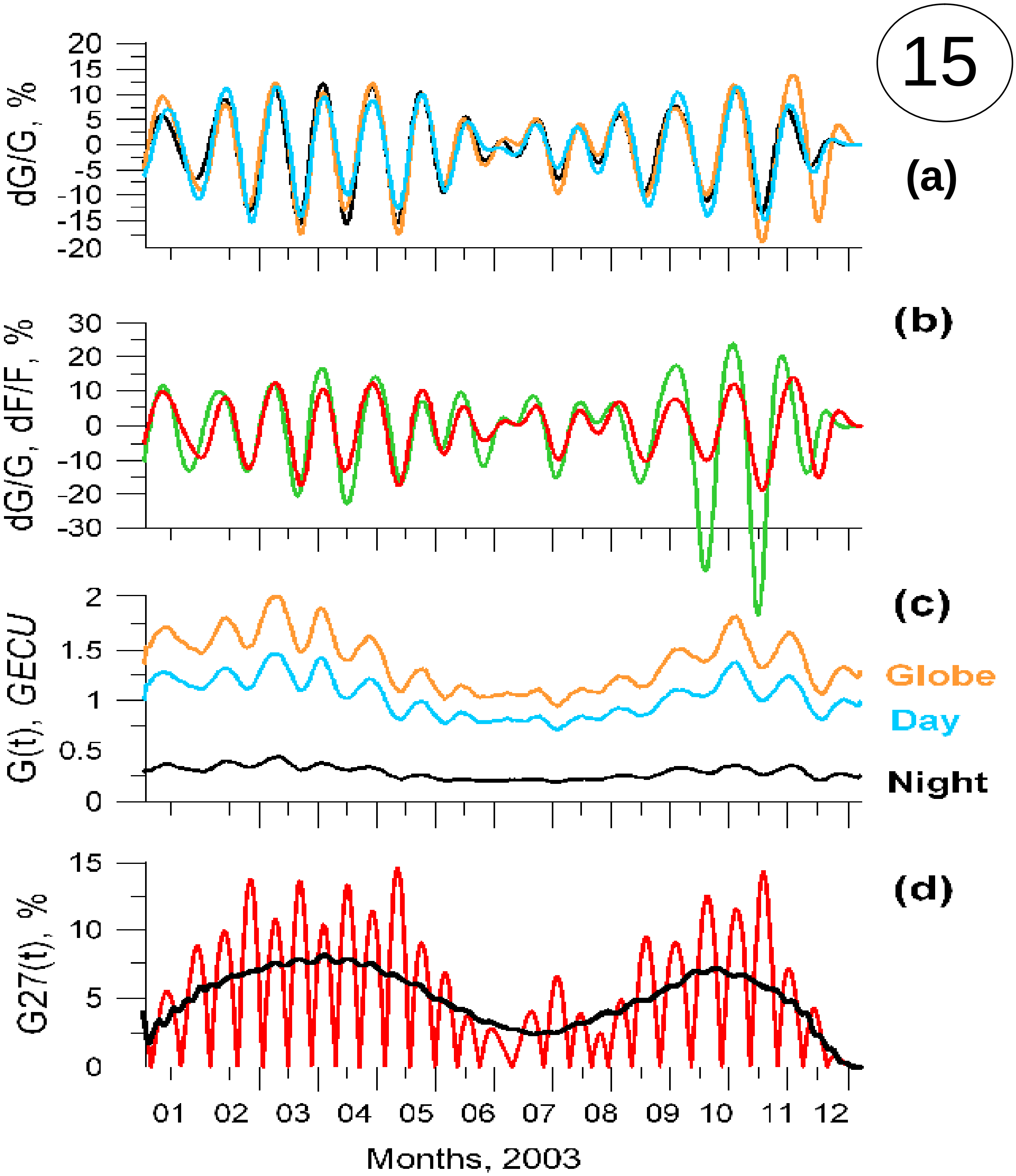
The condition of the Earth’s ionosphere is mainly determined by the solar radiation fluxes within the different wavelength ranges. Many attempts were undertaken to reconstruct the solar radiation characteristics from the ionosphere observational data.

The modern ionosphere monitoring instruments allows determining of local ionosphere parameters, but they have significant global distinctions. This makes difficulties for estimation quantitative solar radiation characteristics from ionospheric data.

On the other hand, an adequate application of solar experimental data is necessary for correction of different ionosphere models used for ionosphere studying and providing of effective satellite and ground-based radio system operating.



Regression dependence between GEC G(t) and the 10.7-cm solar radio flux F(t), smoothed by 10-day (b) and one-year (c) time windows respectively. (a) - the same that on (c), but for G(t) and M(t) variations



Relative amplitude of 27-day variations of G(t) and F(t), filtered in the time period range 20-40 days: (a) - dG/G(t); (b) - G(t) and F(t); (c) - G(t) variations for the entire globe (orange), G(t) of the lighted and darken sides of the Earth. Panel (d) illustrates the calculation procedure of the envelope G27(t) of 27-day GEC variations

2

The poster presents the first results for investiga km). The method of GEC estimation based on th F10.7, but GEC value lags about 30-60 hours as

We developed a method and software for GEC c particular, GEC-IRI values exceed experimental increase as smoothing time window decreases. M

Afraimovich et al. (2006) proposed a new approach for solving these problems. It lies in determining of a global electron content that is equal to the total number of electrons in the near-Earth space environment. The method of GEC estimation and the certain software were developed at the Institute of Solar-Terrestrial Physics SD RAS.

2. Method of Global Electron Content estimation

Our method is based on use of global ionosphere maps (GIM) of total electron content (TEC) generated on a basis of data from International GPS receivers network and presented in the Internet in standard IONEX format. Global electron content G(t) is calculated by summation of the TEC values multiplied by cell's area Si,j over all GIM cells

$$\mathbf{G} = \mathrm{S}\ \mathbf{I}_{\mathbf{i,j}} \bullet \mathbf{S}_{\mathbf{i,j}}.$$

5. Seasonal variations of Global Electron Content

GEC is characterized by strong seasonal (semi-annual) variations with maximum relative amplitude about 10% during the rising and falling parts of the solar activity period and up to 30% during the period of maximum. Maximum GEC values are observed at the equinox time.

The semi-annual GEC variations are not correlated with F10.7 variations. This is illustrated by comparison between filtered relative amplitudes dG(t)/G(t) and dF(t)/F(t) (panel **c** on slide 10). Similar dependencies for dG(t)/G(t) and dM(t)/M(t) (panel **b)** are in the good agreement.

However some significant distinctions between model and experimental GEC values was found. In particular the maximums of the model and experimental curves do not coincide (slide 11). The lag between model and experimental values can reach several tens of days in the both ways.

It is known that response of the ionosphere to ultraviolet radiation flux changes is determined by the lag time and the recombination time constants, which is equal to 1 hour. Founded lag of the 27-day GEC variations relative to corresponding changes of the F10.7 flux can be caused by significantly greater time constants that characterize thermosphere as GEC variations.

We also estimated the 27-day variations amplitude envelope during the solar activity period. Panel **d** (slide 15) illustrates the procedure of calculation of the envelope G27(t) for relative amplitude dG/G(t) of 27-day GEC variations shown in panel **b** by red.
Slide 17 presents the envelope of 27-day variations of GEC (G27(t), red) and of 10.7-cm solar radiation flux (F27(t), green) during the 23rd cycle of solar activity (1998-2005), smoothed by 365-day time window (**b**) and 81-day window (**c**). Panel **d** shows the same as panel **c**, but for solar Lyman-alpha irradiance at 121.67 nm.

Global ele
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E.L. Afraimovich*[1]*, E.I. A

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stigation of the dynamics of global electron content (G
on the Global Ionospheric Maps technique (GIM) is p
rs as compared to the F10.7. Besides GEC has seasona

EC calculation using IRI-2001 (GEC-IRI). Compariso
ental GEC values for upper integration height higher t
es. Mainly this reflects the fact that IRI is a median ion

Afraimovich et al. (2006) have suggested a unit of GEC GECU, which is equal to 10^{32} electrons.

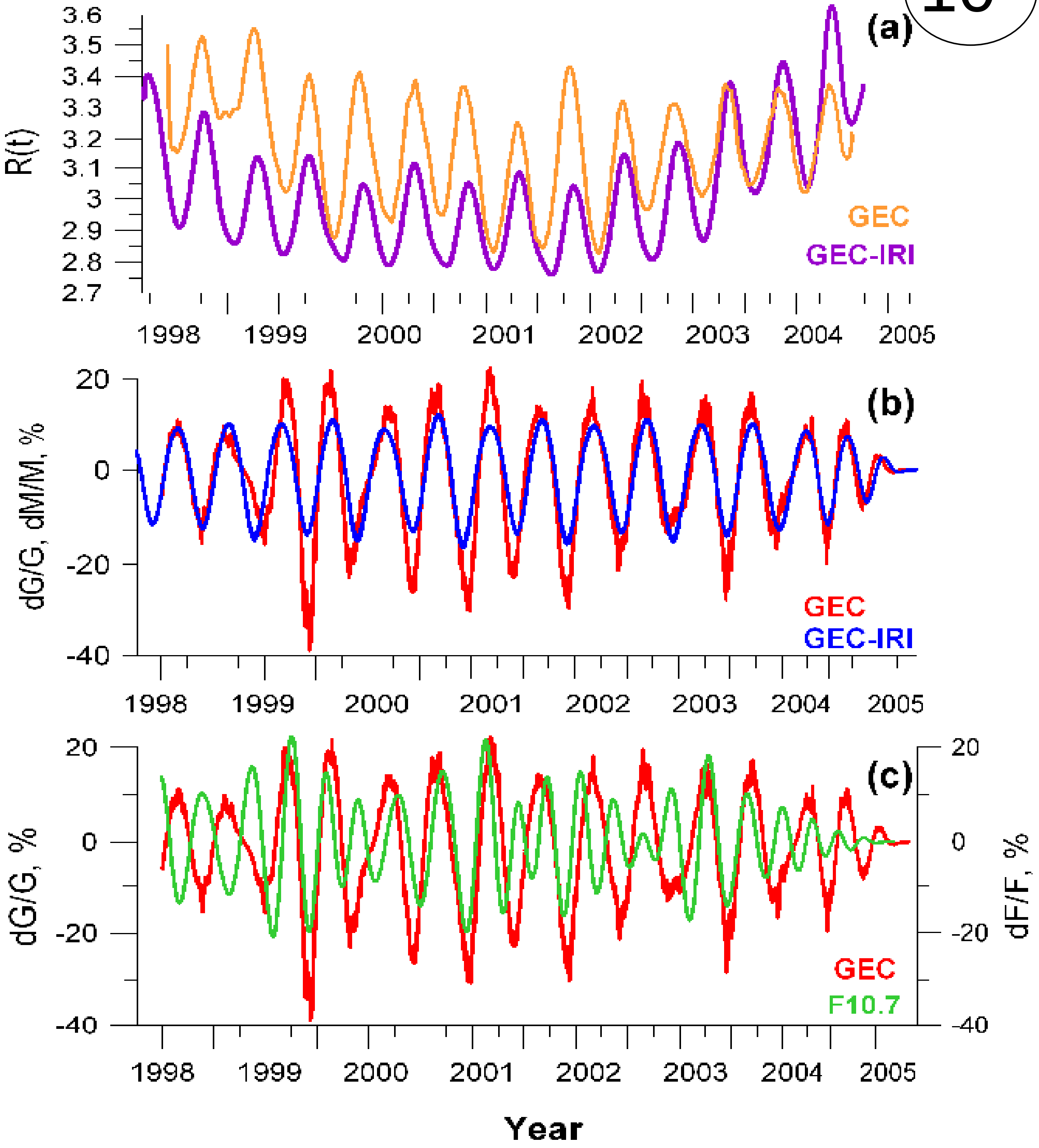
Slide 4 presents GEC variations G(t) calculated using data of the different laboratories. Relative GEC deviations (%)

$$S = \left[\frac{GEC_A - GEC_B}{GEC_A} \right] \cdot 100\%$$

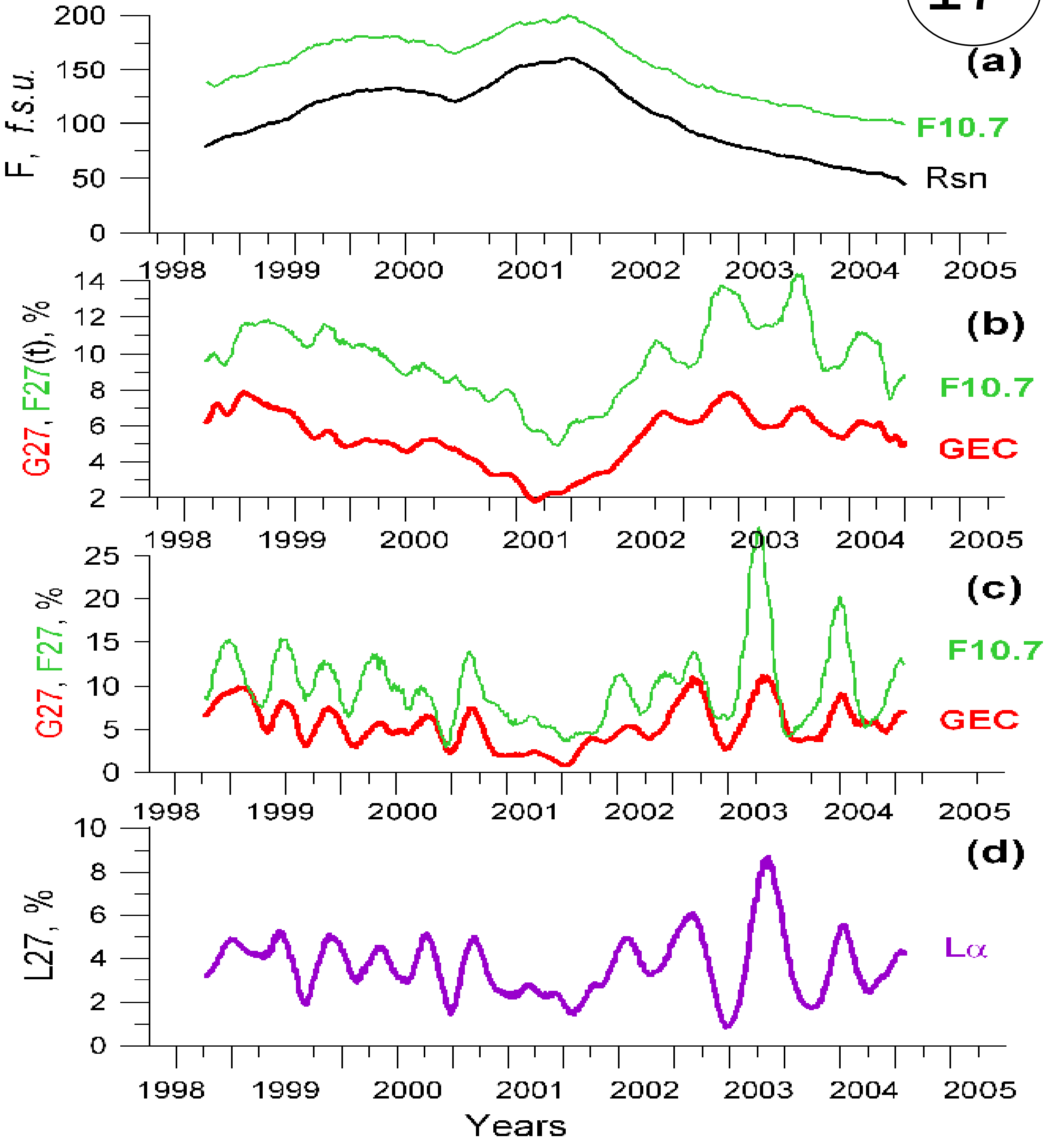
and RMS (%) for different laboratories data smoothed by 10-day window are also presented in the Table 1.

Table 1

N	**Year**	**JPLG-CODG, %**	**JPLG-UPCG, %**	**JPLG-ESAG, %**
1	1999	14,8±2,3	12,1±3,4	16,9 ±1,7
2	2000	13,7±2,9	3,2±3,3	12,6 ±3,6
3	2001	10,5±5,2	4,2±2,7	9,8 ±2,8
4	2002	5,3±5,8	4,6±5,8	10,8 ±4,5
5	2003	7,0±2,5	9,4±5,9	13,4 ±2,7
6	2004	10,7±7,3	10,9±3,8	16,1 ±3,6
7	2005	13,1±1,9	12,6±2,3	15,8 ±3,0



(a) - the ratio R(t) of the lighted and darken sides of the Earth for G(t) and for M(t); (b) - relative amplitude (%) of G(t) and M(t) variations filtered in the time period range 100-300 days; (c) - the same, but for G(t) (red) and F(t) (green)



The envelope of 27-day variations G27(t) of GEC and F27(t) of the 10.7-cm solar radio flux – (b, c); (d) - emission of Lyman-alpha irradiance; (a) - dependencies of the 10.7-cm solar radio flux F(t) and daily value sunspot number Rsn

ectron content and
rison with IRI mod

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Solar-Terrestrial Physics SD RAS, Irk
and Radiowave Propagation, FED RA

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I) is proposed. We analyze data for period 1998-2005.
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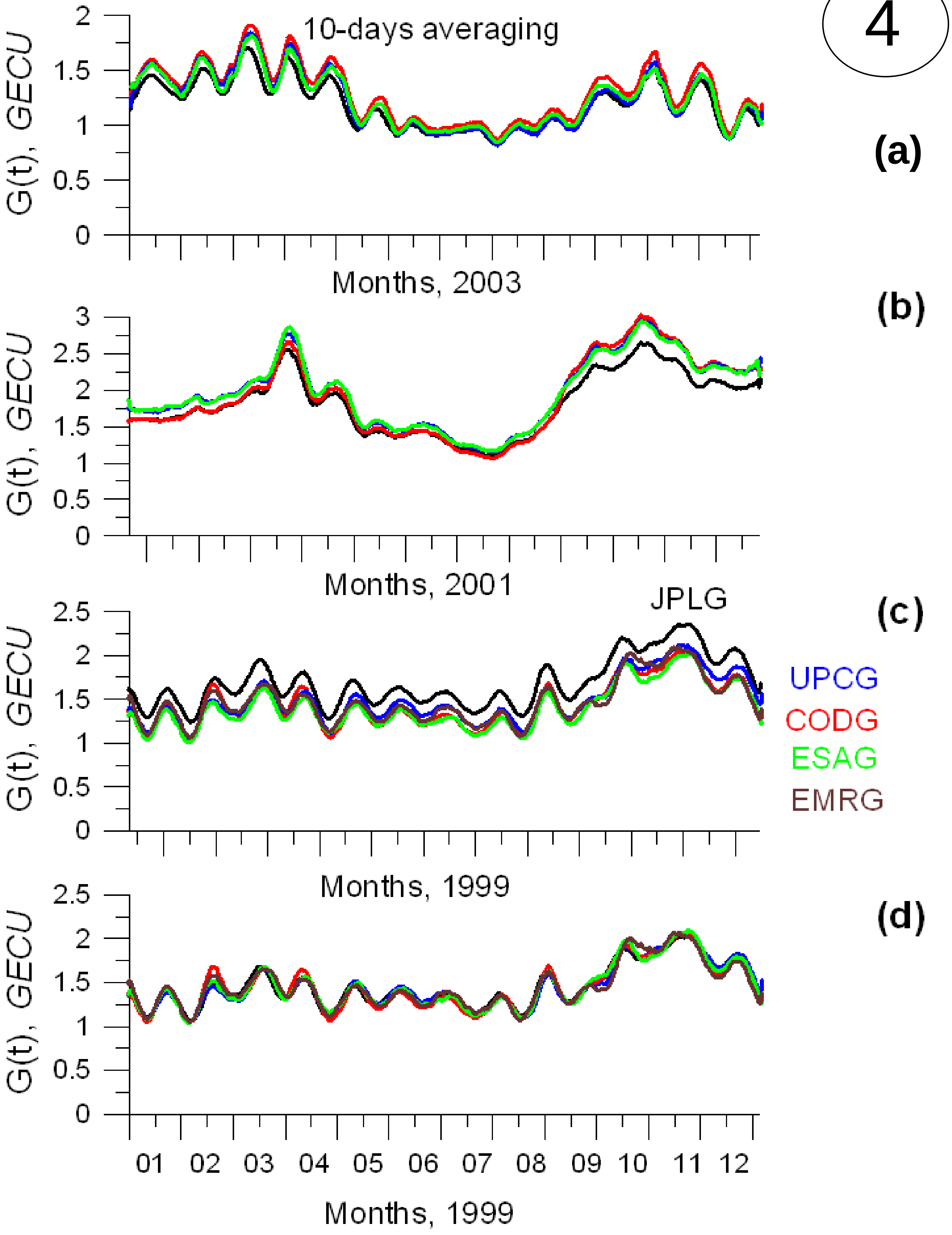
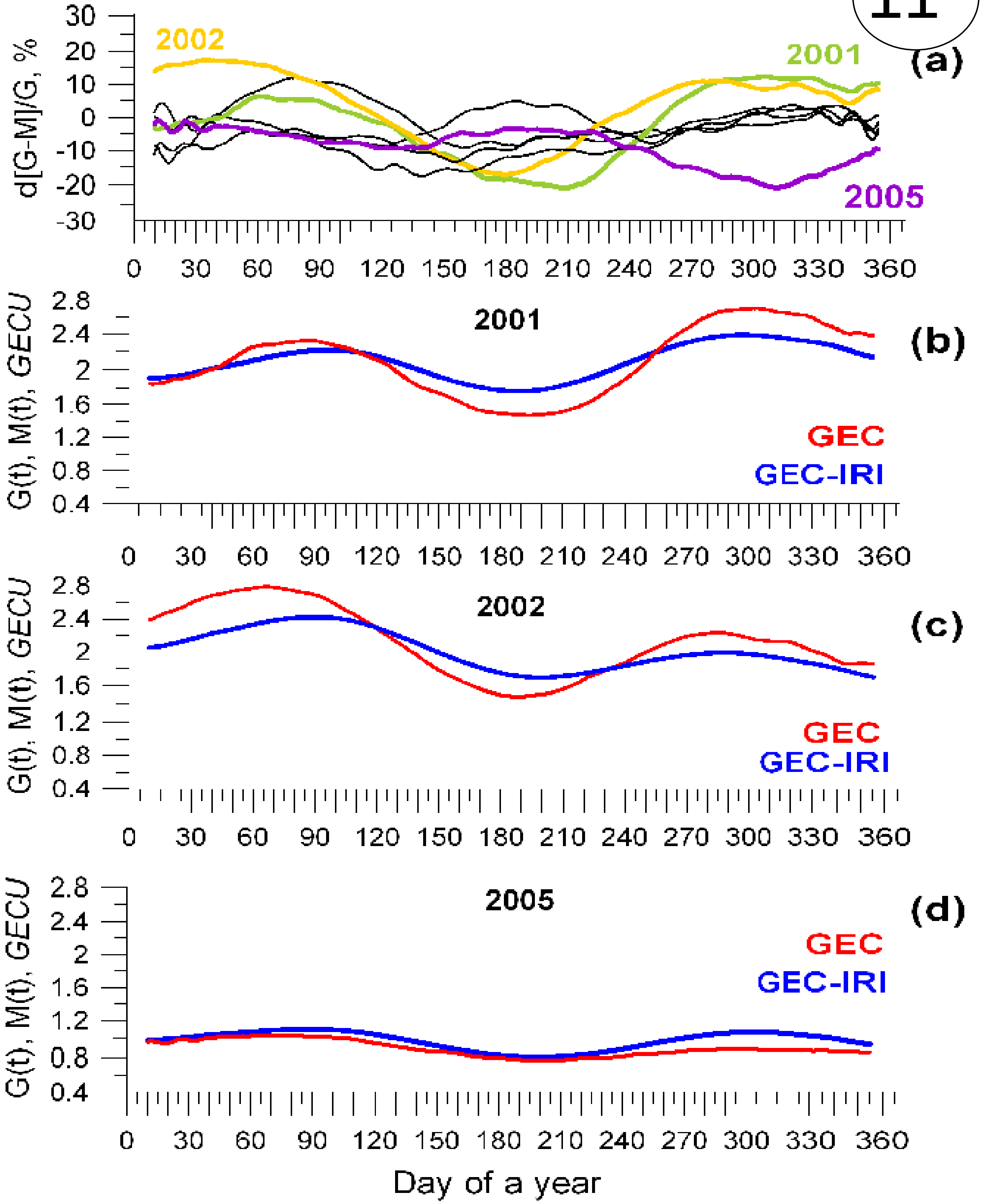
in ionosphere model and do not take into account day-t



GEC from the [JPLG, CODG, ESAG, UPCG] IONEX data for 1999; (a, b, d) - the same that on (c), but for normalized GEC data for the 2003, 2001, 1999



(a) - 1999-2005 dependencies of the relative difference between G(t) and M(t) variations (d[G-M]/G) smoothed with the 81-day time window; (b-d) - the G(t), and M(t) for the 2001, 2002, 2005

The results of comparison between modeled GEC M(t) and experimental GEC G(t) smoothed by different time windows are summarized in Table 2.

Table 2

N	**Year**	**Time window, days**	**[G(t)-M(t)]/G(t), %**	**RMS,%**
1	1998-2005	365	-1,5	5,0
2	1999	81	-1,4	4,3
3	2000	81	-1,3	7,0
4	2001	81	-1,6	10,7
5	2002	81	3,6	10,0
6	2003	81	-7,1	5,7
7	2004	81	-6,1	3,4
8	2005	81	-8,6	5,6
9	1999	10	-1,98	10,5
10	2000	10	-1,98	11,0
11	2001	10	-2,81	15,1
12	2002	10	2,88	13,7
13	2003	10	-7,8	11,0
14	2004	10	-6,5	8,6
15	2005	10	-9,3	9,2

solar activity:
leling results

.V. Yasukevich[1], I.V. Zhive

utsk, Russian Federation
S, Petropavlovsk-Kamchatskii, Russia

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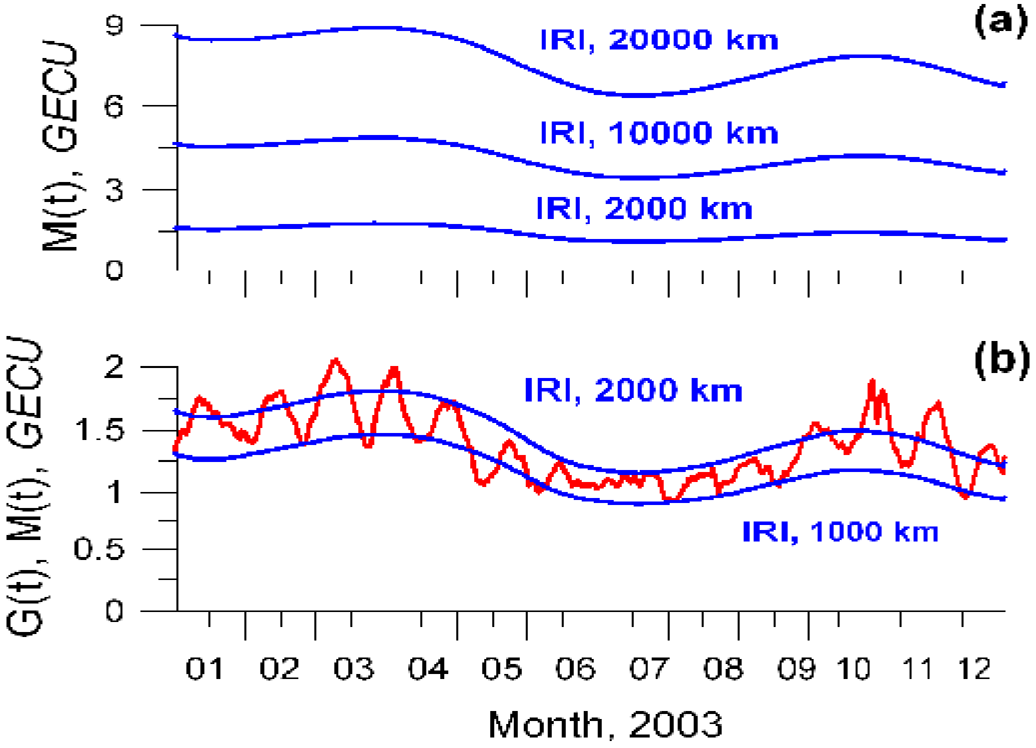
3. Global Electron Content modeling

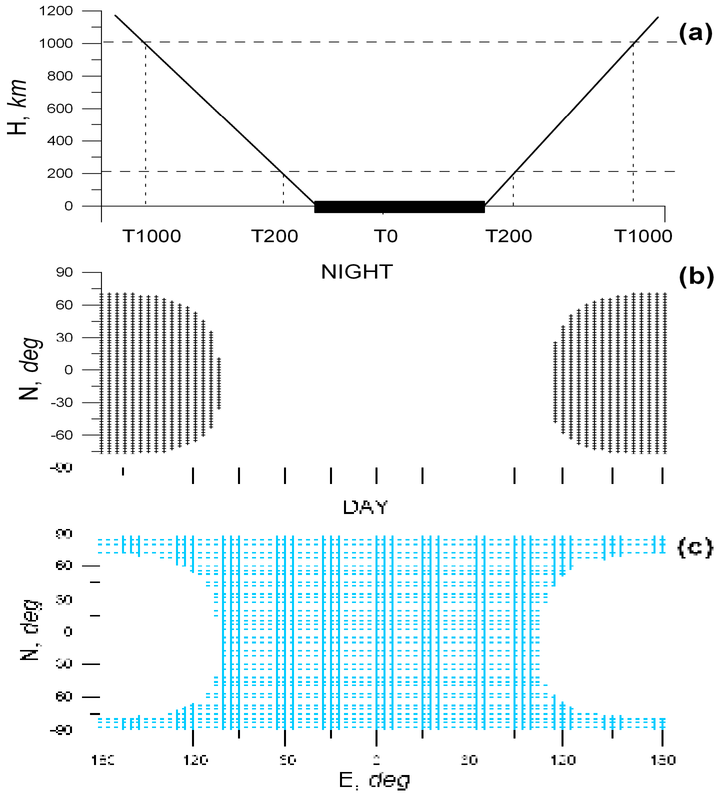
For GEC test modeling we chose well-known and widely used international empirical model of ionosphere IRI-2001 and we developed a corresponding software. The main parameter in the case of TEC calculation in IRI-2001 is upper height for electron density profile integration h_{max}.



As shown on the figure IRI model significantly overestimates GEC values M(t) (blue), but for h_{max}=2000 km they lie more closely to experimental one (red). Therefore, hereinafter all estimations were performed for h_{max} =2000 km.

6. Global Electron Content of the lighted and darken sides of the Earth

To understand the physical mechanisms and comparison with model we also calculated GEC for lighted G_d and darken G_n sides of the Earth and their ratio $R=G_d/G_n$. For G_d and G_n the summation (formula, slide 3) is carried out only for GIM cells that are located inside or outside the solar terminator border determined for a certain altitude H in the atmosphere. On the figure oblique lines mark a shadow boundary at different altitudes in the ionosphere (panel **a**). The lighted zone boundaries T0, T200, T1000 correspond to altitude values H = 0, 200, 1000 km. Panels **b** and **c** show areas for darken and lighted sides of the Earth for March 31, 2003, for H=200 km and 12 UT.



8. Conclusion

1. The systematic deviations were found between GEC values calculated on the base of the different laboratories IONEX data presented in the Internet (JPLG, CODG, ESAG, UPCG).

2. During the period 1998-2005 the average level of GEC varied from 0.5 to 3.5 GECU. 27 day variations of GEC are very similar to the ones of the index F10.7, but GEC undergoes a lagging of about of 30-60 hours. GEC has seasonal variations with maximum values in equinoctial months. Deep seasonal variations are also typical for a ratio of GEC for the lighted and darken sides of the Earth. Maximal values of this ratio were observed during the periods of summer and winter solstices.

3. We developed the method and software for GEC estimation using IRI-2001 (GEC-IRI) and compared its results with experimental GEC values during the

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ded by the GPS orbital altitude (about 20000
EC are very similar to the ones of the index

here are also some significant distinctions. In
ween GEC-IRI and experimental GEC series
rs (e.g. 27-day variations).

4. Global Electron Content during the 23rd cycle of solar activity

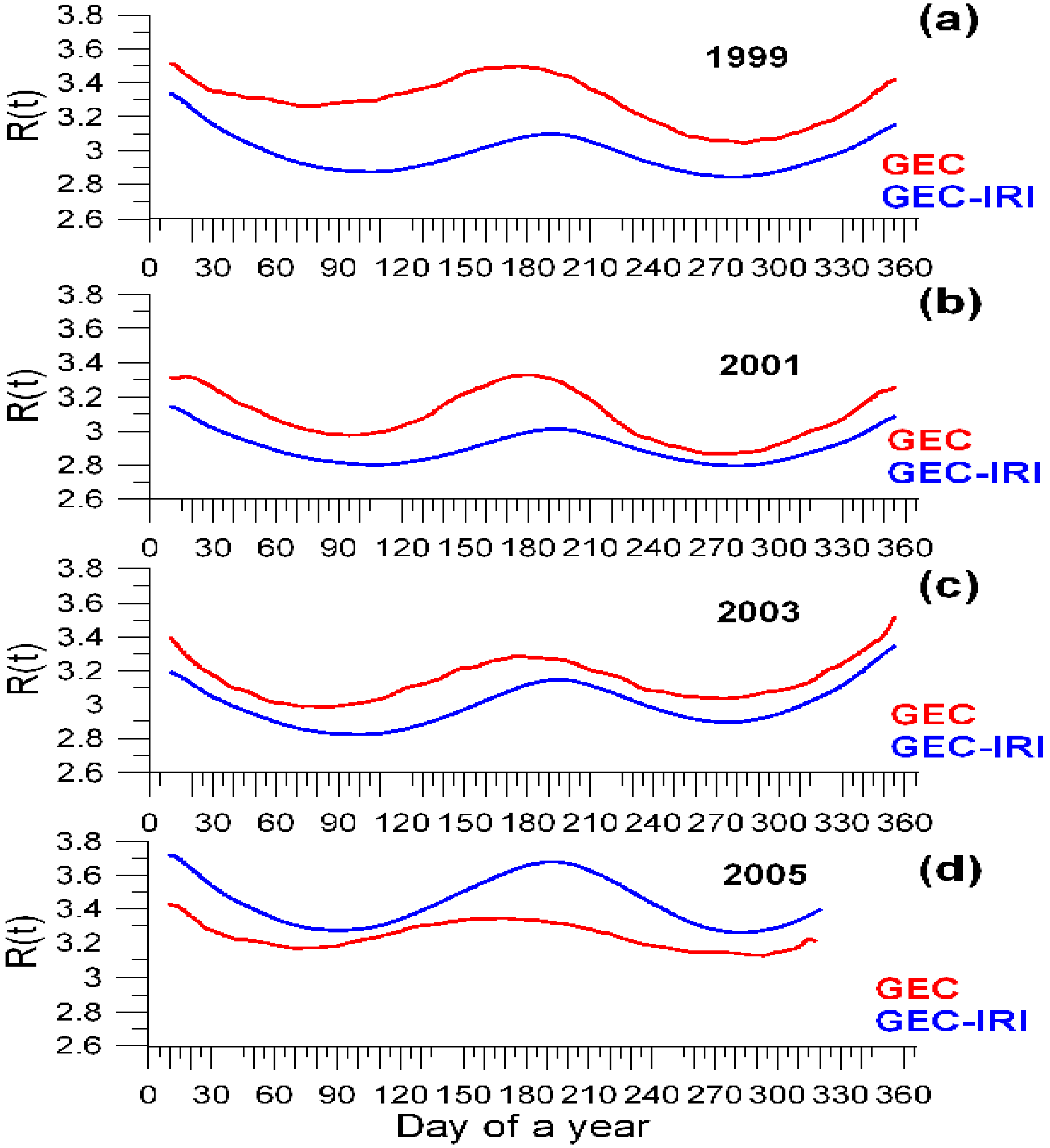
GEC value G(t) (orange on slide 7) illustrates a considerable variability during the 23rd cycle of solar activity: from 0.5 to 3.5 GECU.

A comparison between G(t), M(t) and F(t)- variations of solar activity F10.7 index (green on slide 7) shows good agreement between these values. It is especially clear from panel **d**, where G(t), M(t) and F(t) dependencies were smoothed by one-year time window.

Regression dependence of GEC from F10.7 index during the period 1998-2005 is shown on slide 8. Smoothed GEC and F10.7 series regression (panel **d**) is well approximated by linear dependence.

The regression dependence of experimental to model GEC values smoothed by one-year time window is also well approximated by linear dependence (panel **a** on slide 8).

Calculations we have carried out for altitude H = 200 km that is close to the altitude range of the most intensive ionization process of the atmosphere by ultraviolet solar radiation.



A ratio R(t) of the lighted and darken sides of the Earth of G(t) (red) and of M(t) (blue) for the 1999, 2001, 2003, 2005 period from 1998 to 2005. Good agreement between observational and model data for GEC was found in general, but there are some distinctions.

4. Significant overestimation of GEC-IRI values is perceptible for upper integration heights higher than 2000 km (up to 5-6 times for GPS satellites altitude, 20000 km).

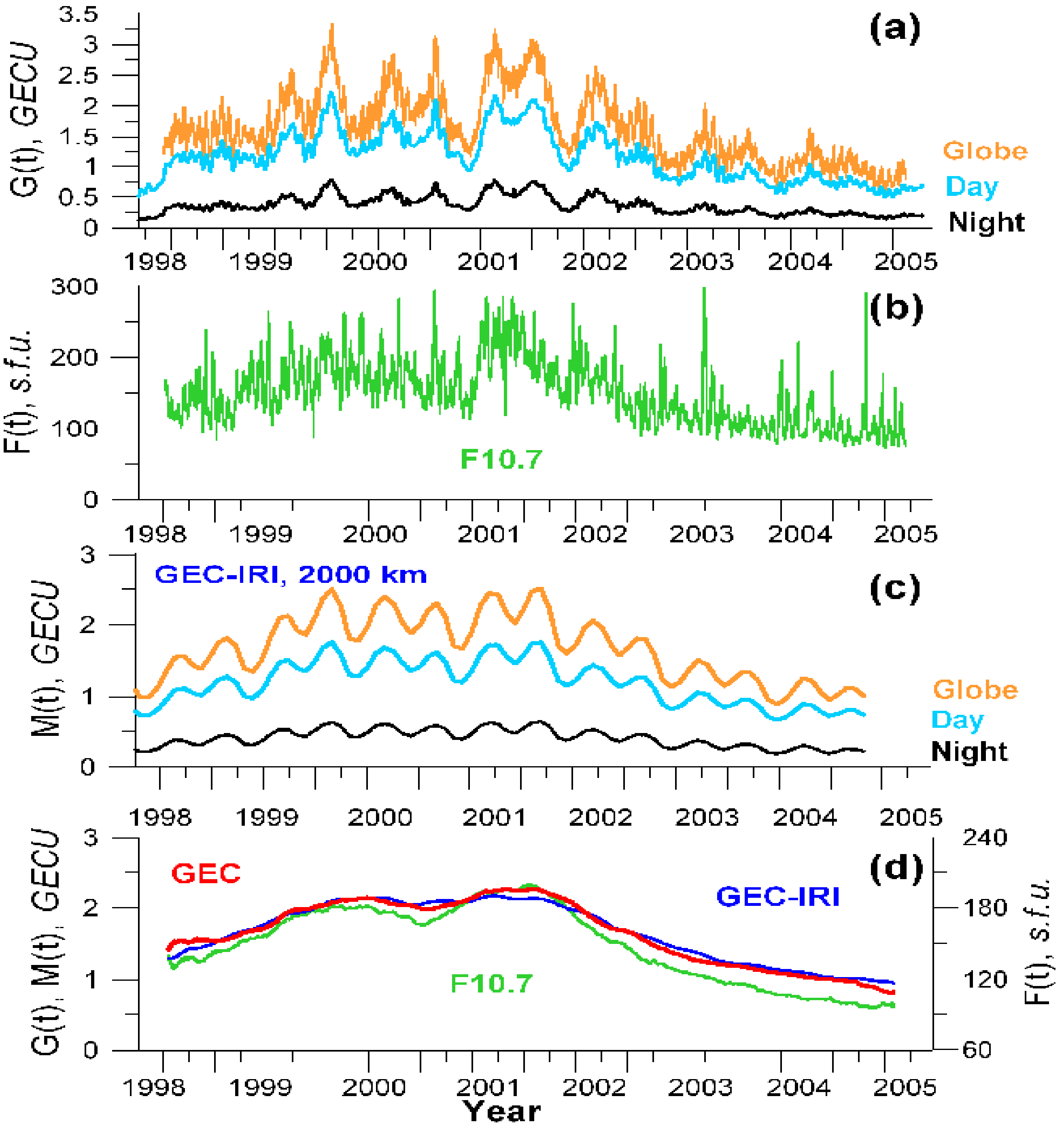
5. It was found that GEC-IRI seasonal variations are out-of-phase with experimental GEC values. A ratio of GEC-IRI of the lighted and darken sides of the Earth is lower (from 2.8 to 3.2) than the one for experimental GEC.

6. Relative difference and RMS between GEC-IRI and experimental GEC series increase as smoothing time window decreases. Mainly this reflects the fact that IRI is a median ionosphere model and do not take into account day-to-day variations of the ionosphere parameters (e.g. 27-day variations). The minimal relative difference

This poster preparation is based on papers:

1. Afraimovich E.L., E.I. Astafyeva, I.V. Zhivetiev, 2006. Solar activity and global electron content. Doklady Earth Sciences (accepted).

2. E.L. Afraimovich, E.I. Astafyeva, A.V. Oinats, Yu.V. Yasukevich, I.V. Zhivetiev, 2006. Global electron content as a new index of solar activity. Comparison with IRI modeling results. IRI News (accepted).



(a) - GEC variations G(t); (b) - the 10.7-cm solar radio flux F(t); (c) - the IRI-2001 model estimation of GEC M(t); (d) - smoothed with the 365-day time window G(t), F(t) and M(t)

7. 27-day variations of Global Electron Content

One of the main factors of solar radiation influence on the ionosphere state is quasi 27-days variations caused by solar rotation. However, quasi 27-day modulation of local ionosphere parameters can be masked by many other factors. The latter makes impossible to derive reliable numerical characteristics of the 27-day variations of the solar ultraviolet radiation. Global electron content reflects more clearly this feature of solar ultraviolet radiation.

Slide 15 shows time dependencies of relative amplitude dG/G,% of 27-day variations of G(t) and F(t) smoothed by the 10-day time window (for 2003). Correlation analysis displays high similarity between 27-day variations of the G(t) and F(t) (maximum correlation coefficient is more than 0.8). Besides, we found that 27-day GEC variations lag for 1.5-2.5 days after the corresponding F10.7 variations (panel **b**).

and RMS values are found for smoothing by one-year time window (about 1.5% and 5% accordingly). As smoothing time window decreases to 10 days the relative difference and RMS increases nearly to 10-15%. Besides the relative difference for 10-day time window increases with year from about 1.5-2% for 1999 to 8-9% for 2005, while RMS values are maximal during the period of high solar activity.

Thus, the data obtained in this study should be of considerable interest for calibration and correction of IRI by using GEC data. The results are also important for studying of the ionization balance caused by solar ultraviolet radiation and by charged particle precipitation in the auroral zones. Combined with the data from the worldwide network of ionosondes, our results can be used in estimating the contribution of the plasmasphere to total electron content.