Dedicated to 100 Years of Professor Karl Rawer

Global characteristics of ionosphere-plasmasphere storms

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Outline

- Background
- Data analysis
- Results
- Discussion and Conclusions
- Acknowledgements
- References

Background

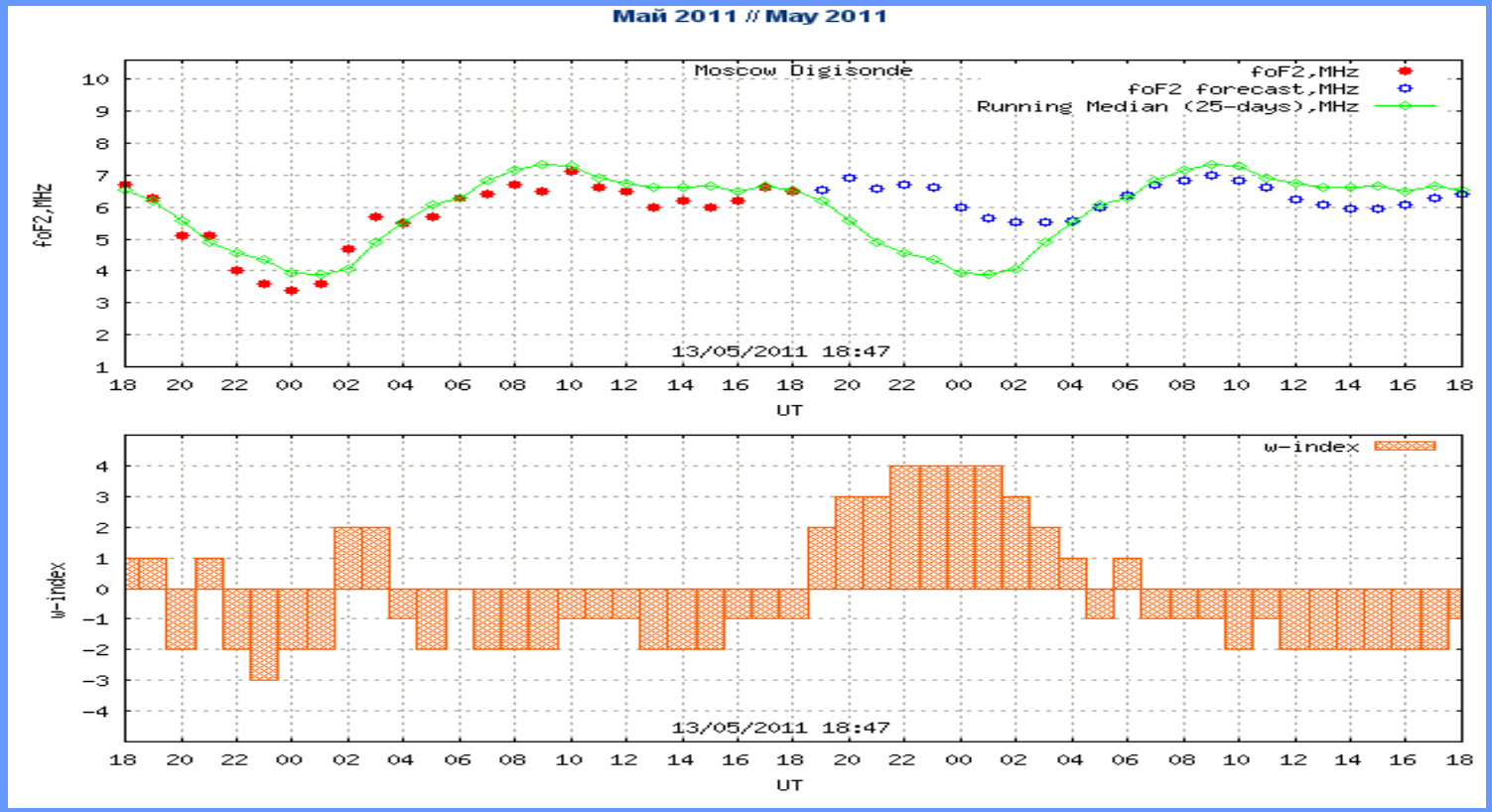
- Global Ionospheric Maps of Total Electron content, GIM-TEC, provided by JPL in the IONEX format (-87.5:2.5:87.5 in latitude, -180:5:180 in longitude) are used as the database for deriving the W-index map
- Planetary Wp index generated from W-index map is used to produce Catalogue of the ionospheric storms since 1999 up-to-date at www.izmiran.ru/services/iweather/storm/

W index specification for TEC (or NmF2)

$D(l)=log(TEC/TECq)$	W	Ionospheric state
$D(l) > 0.301$	4	Intense positive W^+ storm
$0.155 < D(l) \leq 0.301$	3	Moderate W^+ storm
$0.046 < D(l) \leq 0.155$	2	Weak W^+ disturbance
$0.0 < D(l) \leq 0.046$	1	Quiet W^+ state
$D(l)=0$	0	Reference Quiet state
$-0.046 \leq D(l) < 0.0$	-1	Quiet W^- state
$-0.155 \leq D(l) < -0.046$	-2	Weak W^- disturbance
$-0.301 \leq D(l) < -0.155$	-3	Moderate W^- storm
$D(l) < -0.301$	-4	Intense negative W^- storm

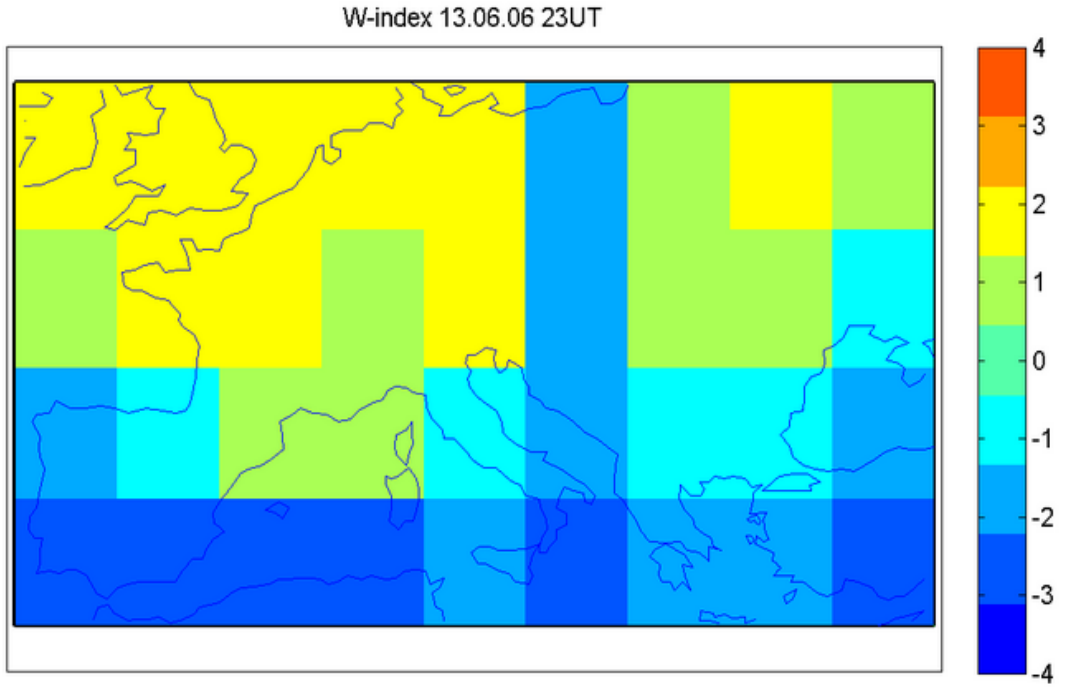
Local W index at Moscow 13.05.2011

http://www.izmiran.ru/services/iweather/

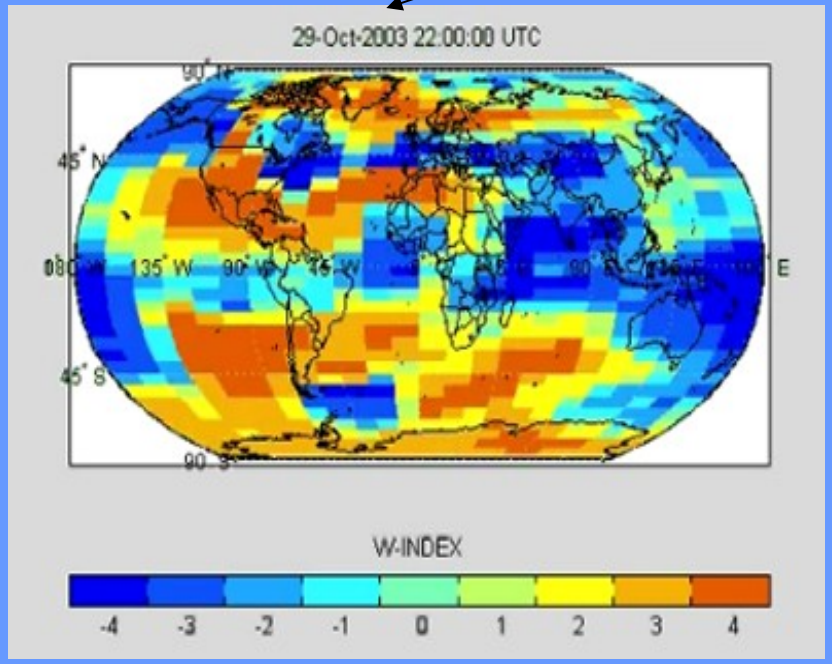


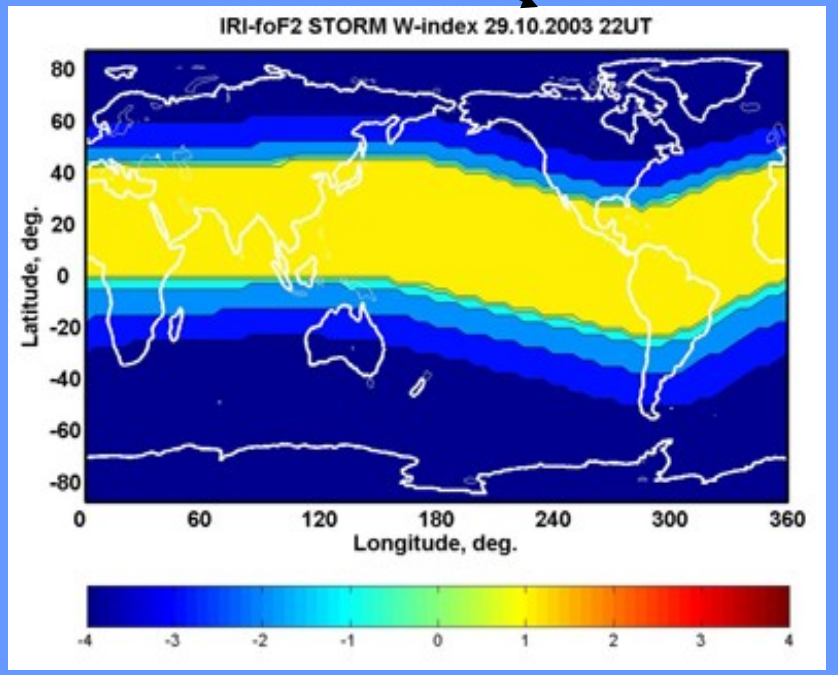
Regional W-index map based on EGNOS-TEC provided at RWC, Warsaw, and archived for a comparison with global W-index maps derived from GIM-TEC [Jakowski et al., 2012; Tomasik et al., 2013].

- ±1 quiet state
- ±2 moderate disturbance
- ±3 moderate ionosphere storm
- ±4 intense ionosphere storm

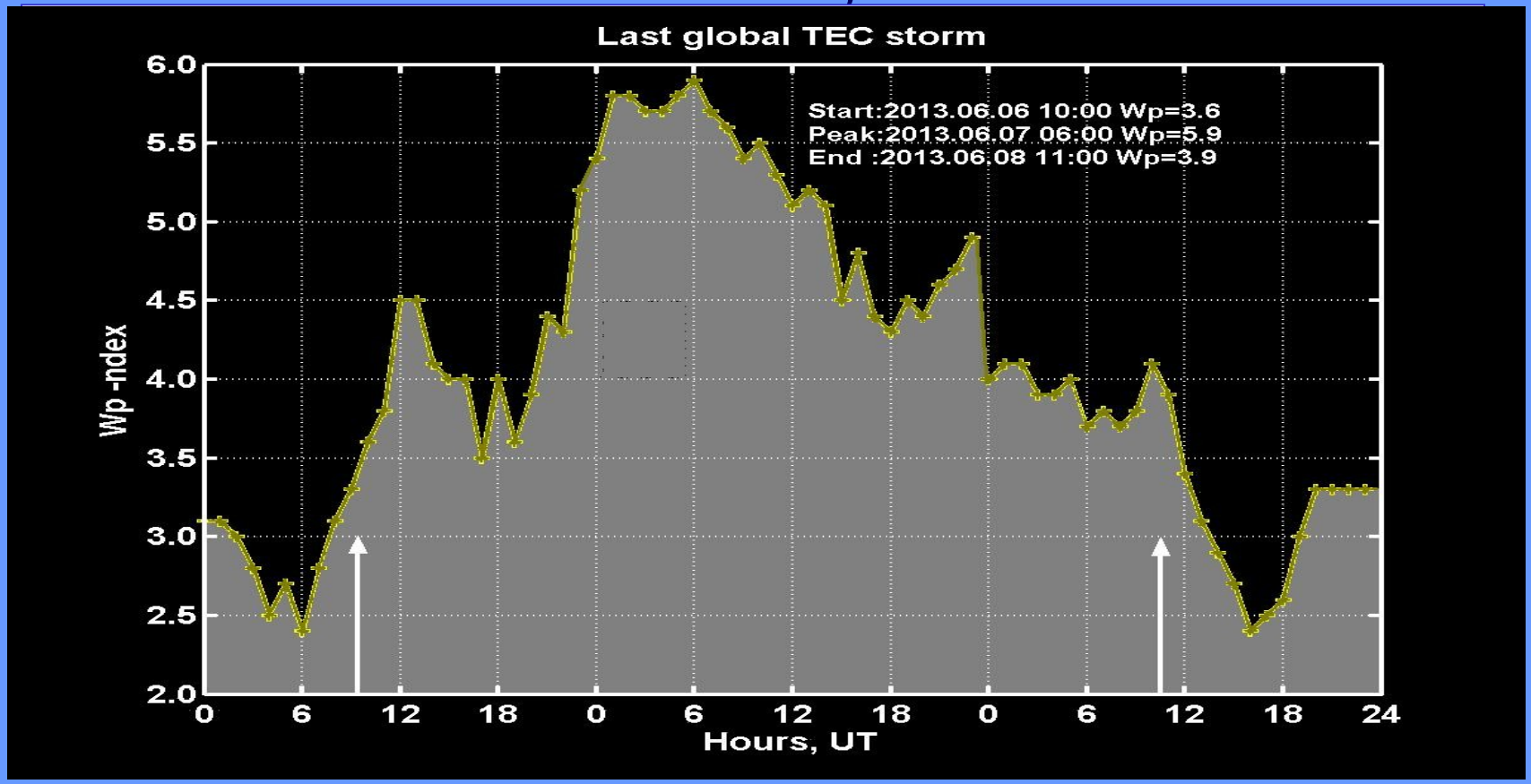


Planetary W-index map of the ionospheric super-storm 30.10.2003 22UT: GIM-TEC-storm (IONOLAB); IRI-Storm-NmF2





Last global Wp-index TEC storm 6 - 8 June, 2013



Planetary Wp & Dst super-storm // Wp, Dst and Ap storms occurrence [Gulyaeva and Stanislawska, 2008]

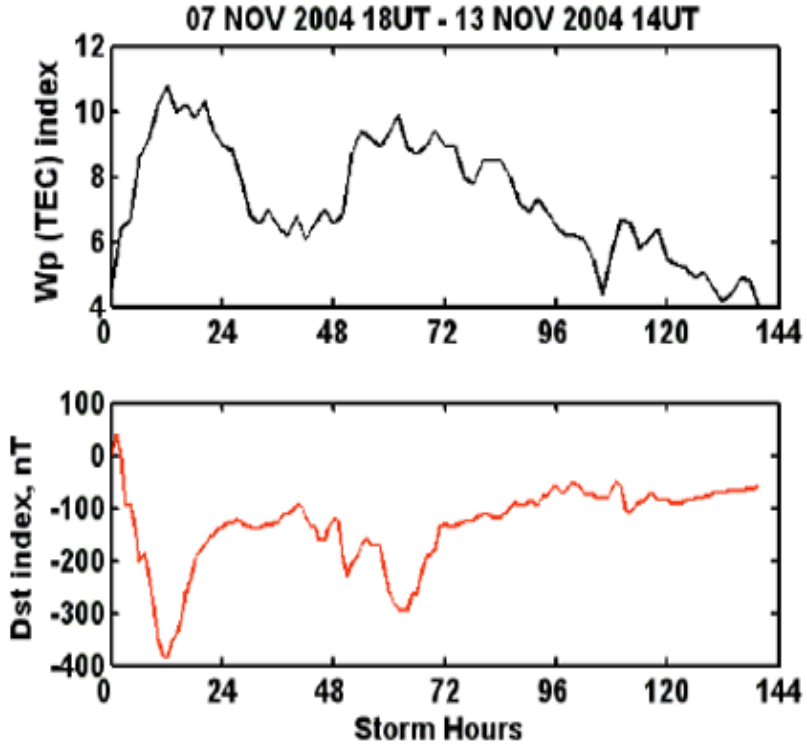


Fig. 2. Coherent ionospheric W_p index and magnetospheric D_{st} index during space weather super-storm on 7 to 13 November 2004.

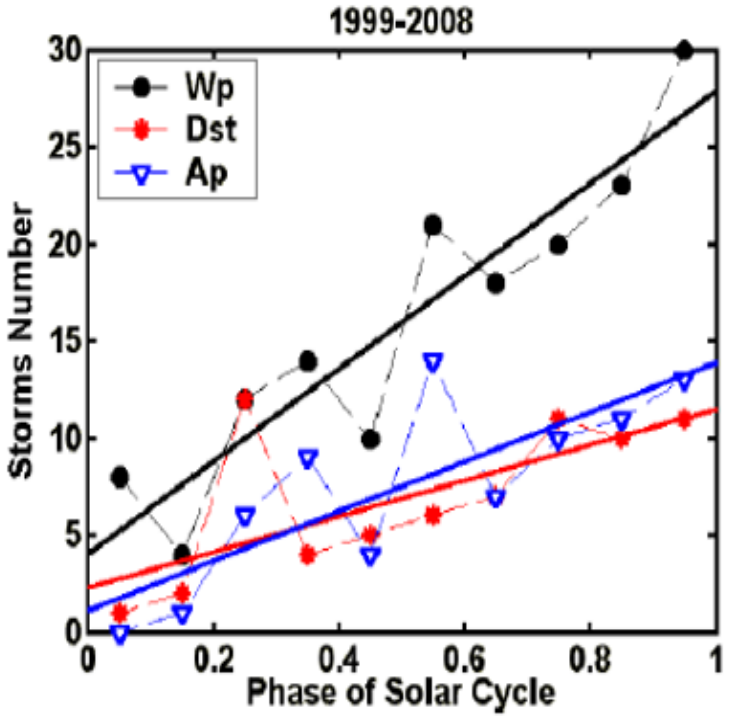


Fig. 3. Solar cycle trend of the number of magnetospheric and plasmaspheric-ionospheric space weather storms observed during 1999–2008.

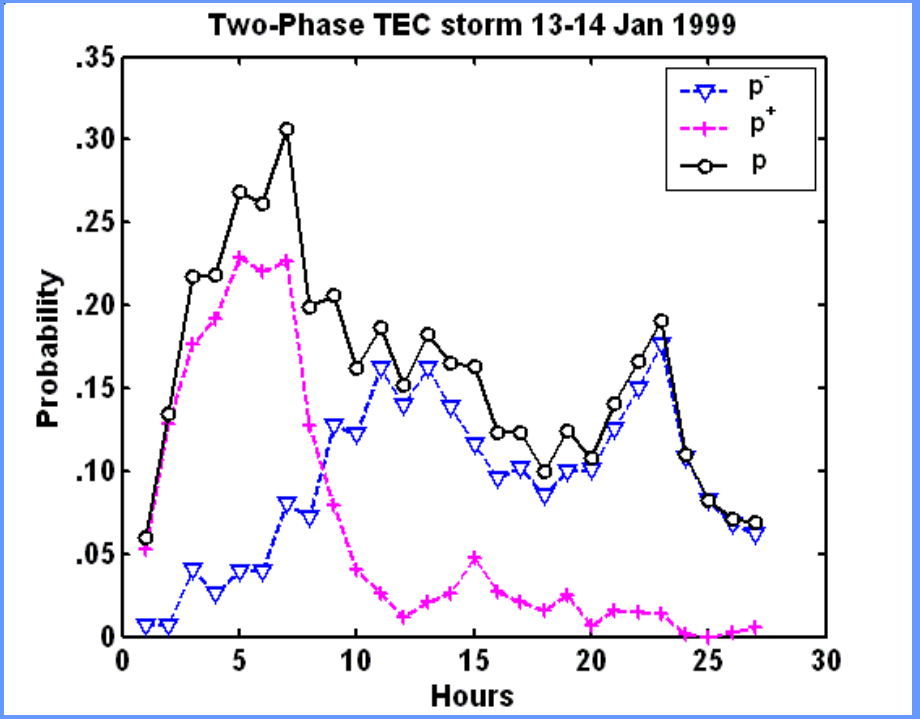
Probability of W^+ and W^- storm occurrence

$$P^+(t) = n_1(W^+, t) / m$$

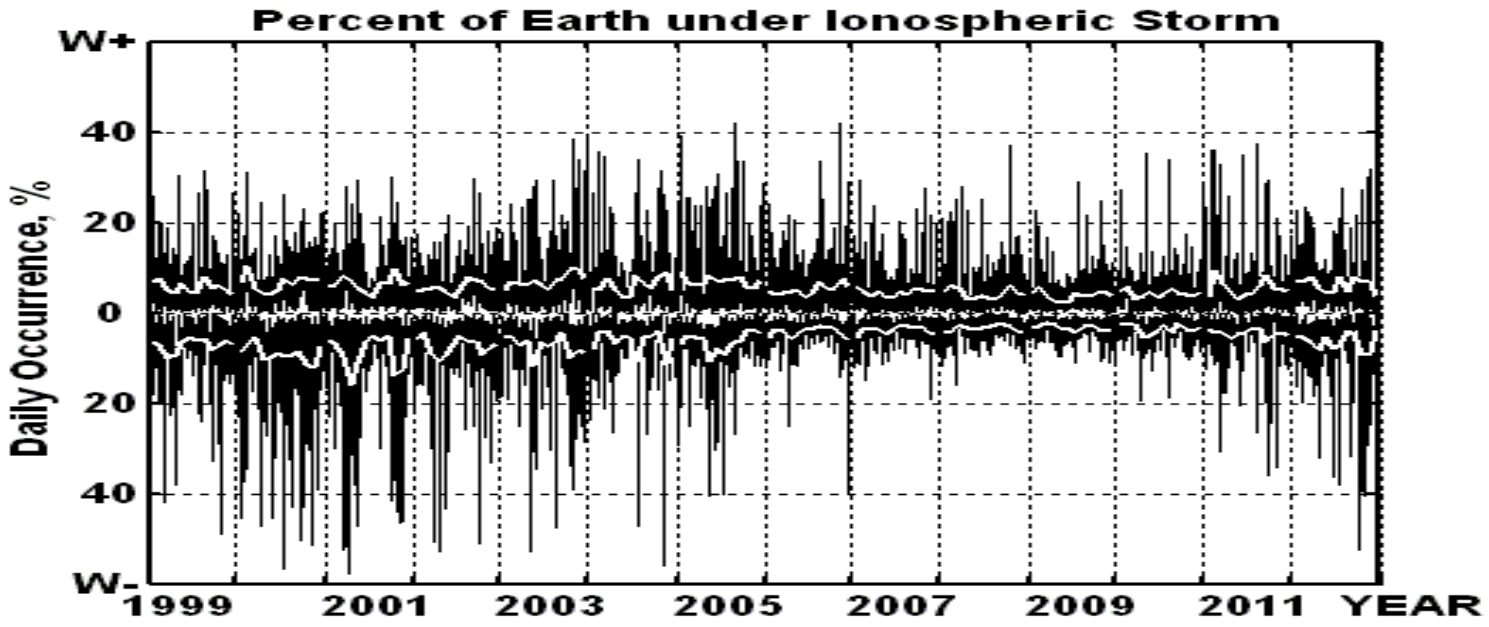
$$P^-(t) = n_2(W^-, t) / m$$

$$P(t) = P^+(t) + P^-(t)$$

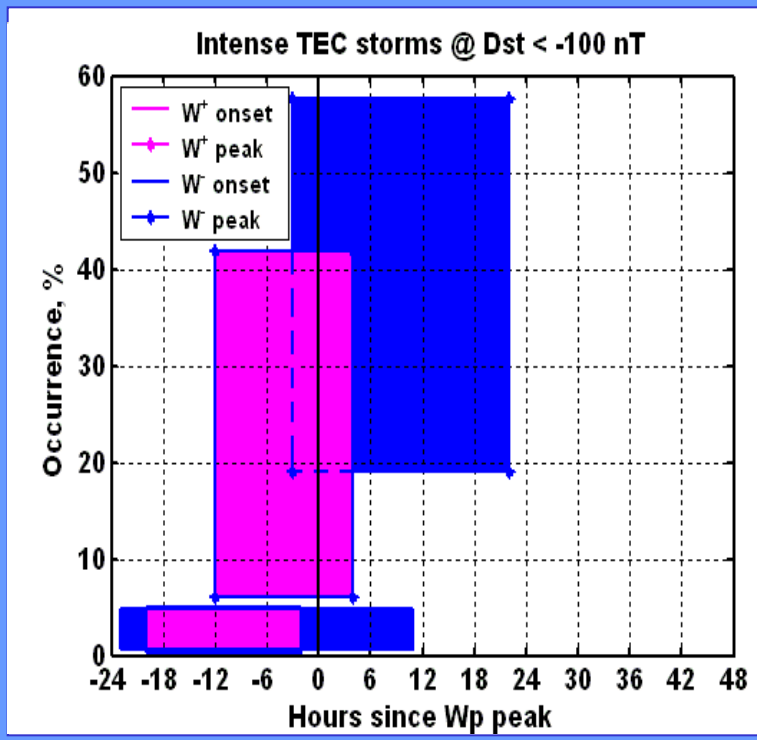
$$m = 5184 \text{ cells}$$

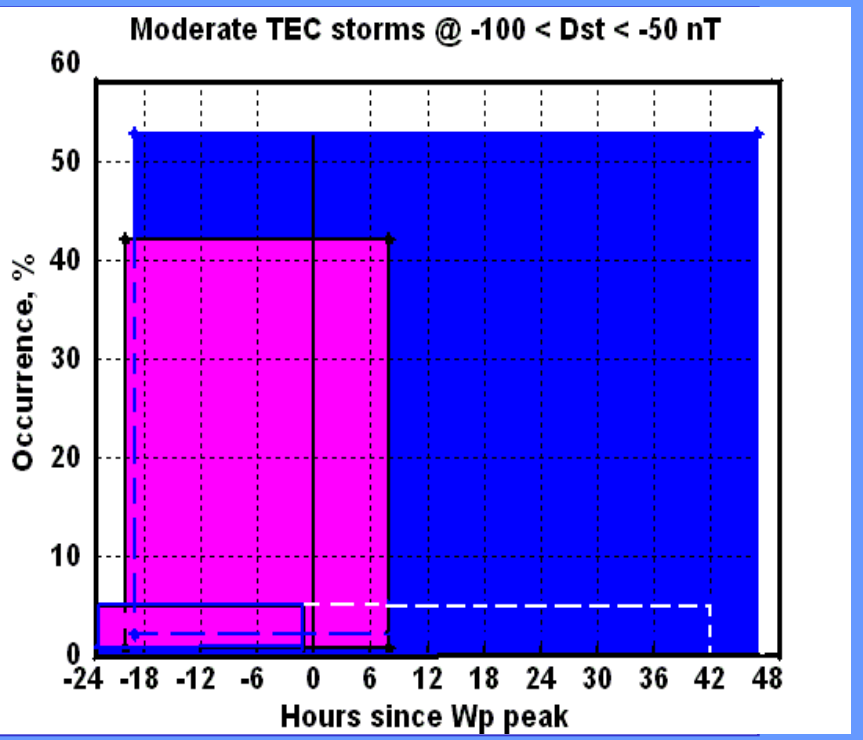


Occurrence, %, of the Earth's ionosphere and plasmasphere under storm conditions: W = 3, 4 (top); W= -3, -4 (bottom) [Gulyaeva et al., 2013]

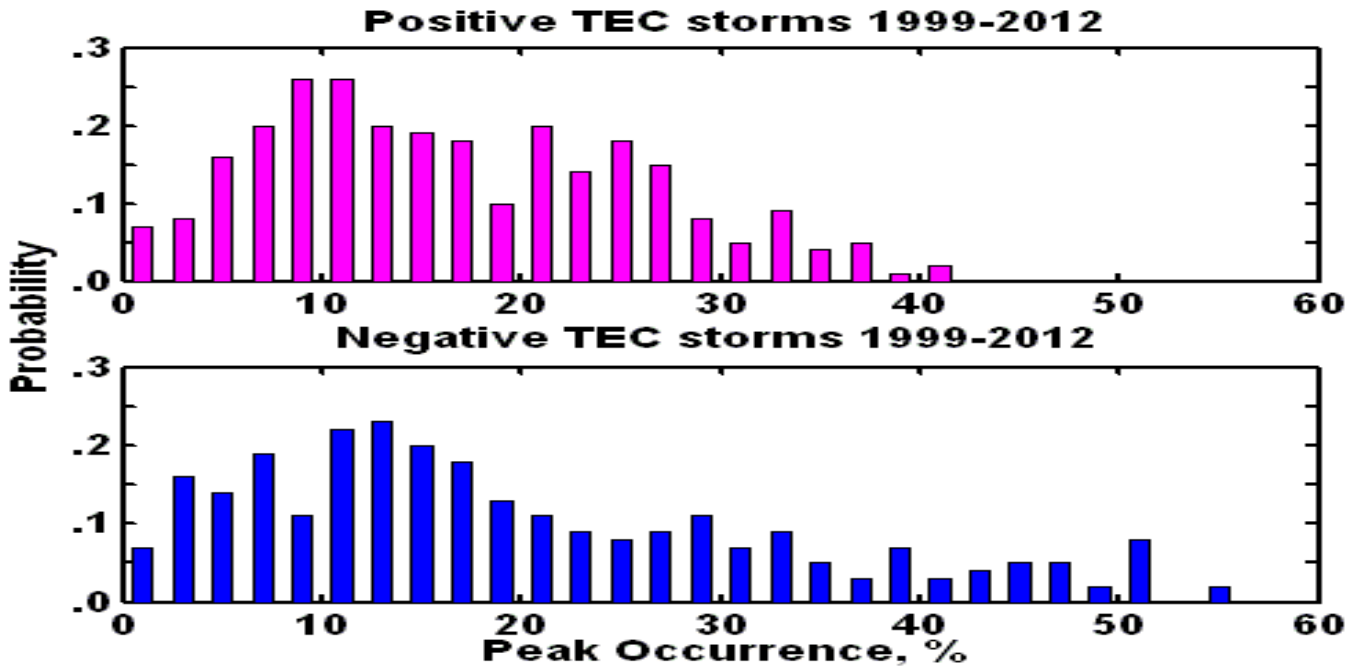


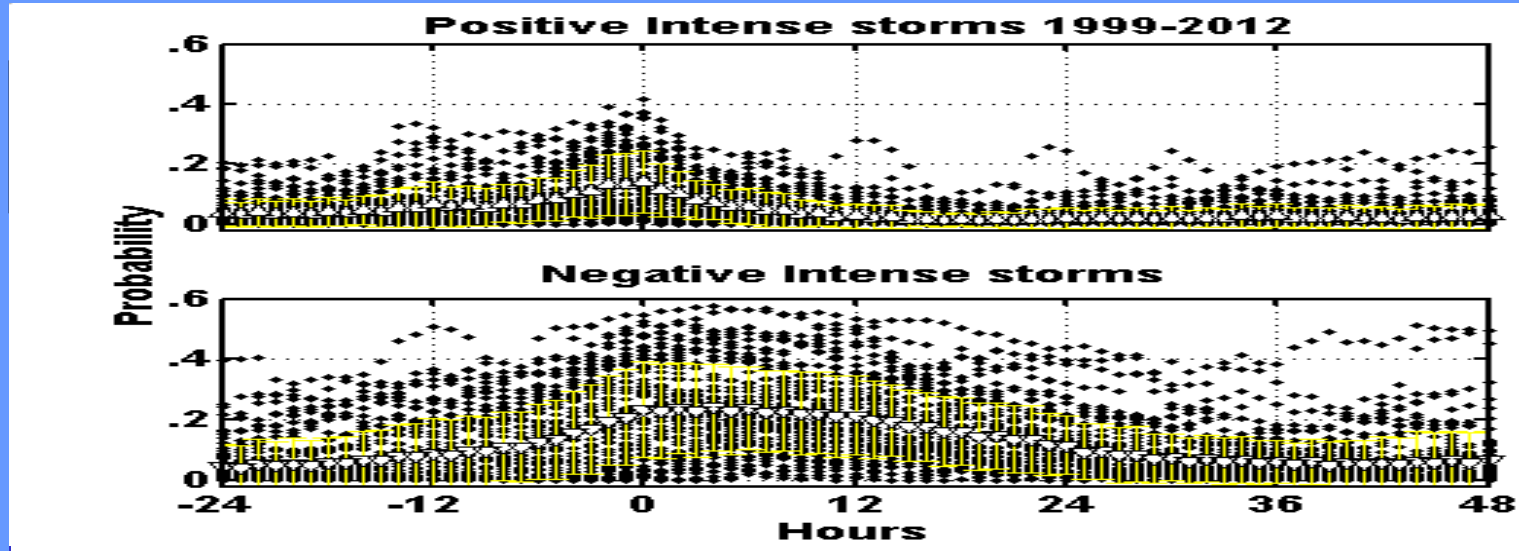
Times of W^+ and W^- storm onset & storm peak and map area, %, under intense storms, Dst<-100, and moderate storms, -100<Dst<-50

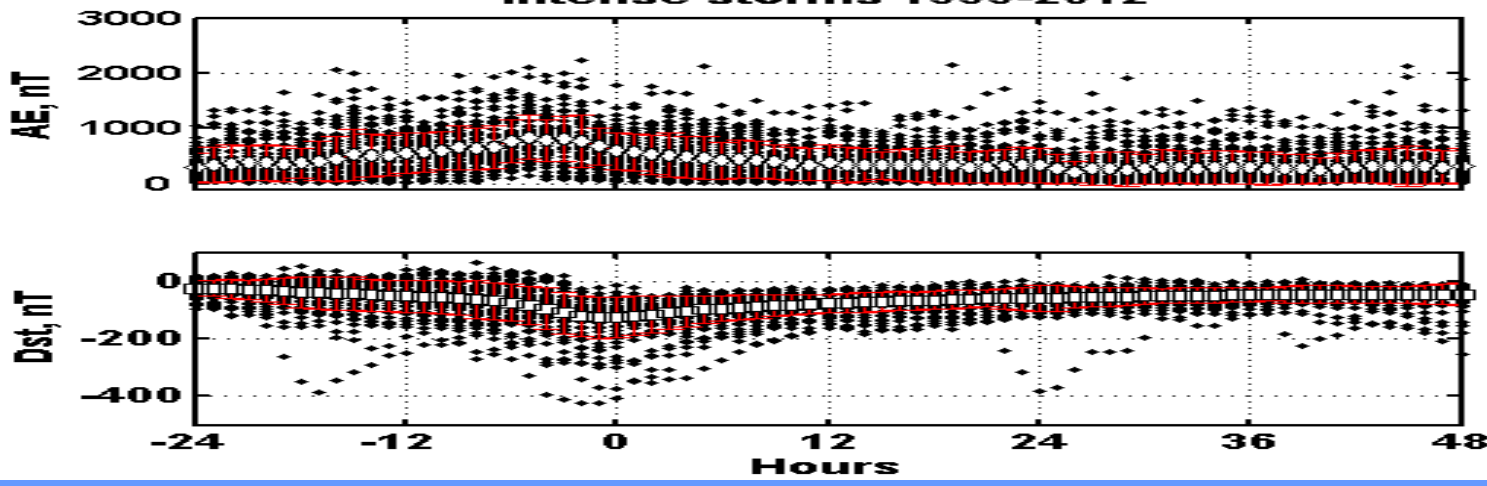


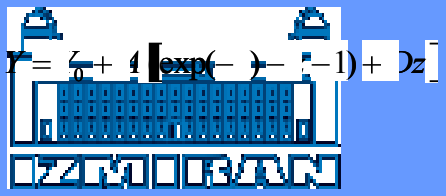


Histogram of probability for TEC positive W^+ storm and negative W^- storm occurrence




Positive Intense storms 1999-2012
Probability
.6
.4
.2
0
Negative Intense storms
.6
.4
.2
0
-24
-12
0
12
24
36
48
Hours


Intense storms 1999-2012
AE, nT
3000
2000
1000
0
Dst, nT
0
-200
-400
-24
-12
0
12
24
36
48
Hours



An empirical analytical function for probability P^+ of W^+ positive storms and P^- for W^- negative storms occurred at Dst storm [Gulyaeva, 2013]:

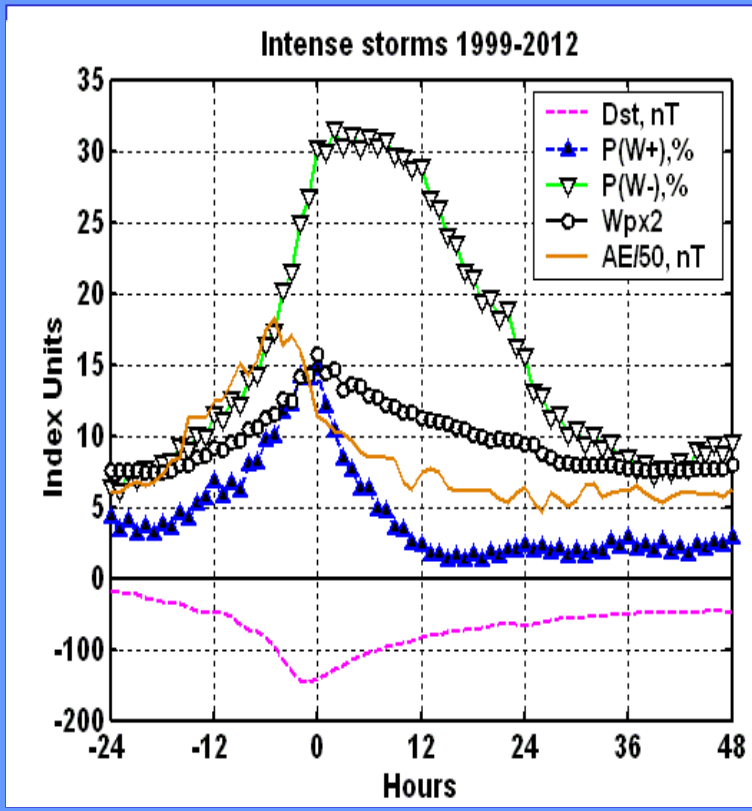
$$P^{\pm} = Po + A[\exp(-z) - z - 1) + Dz],$$

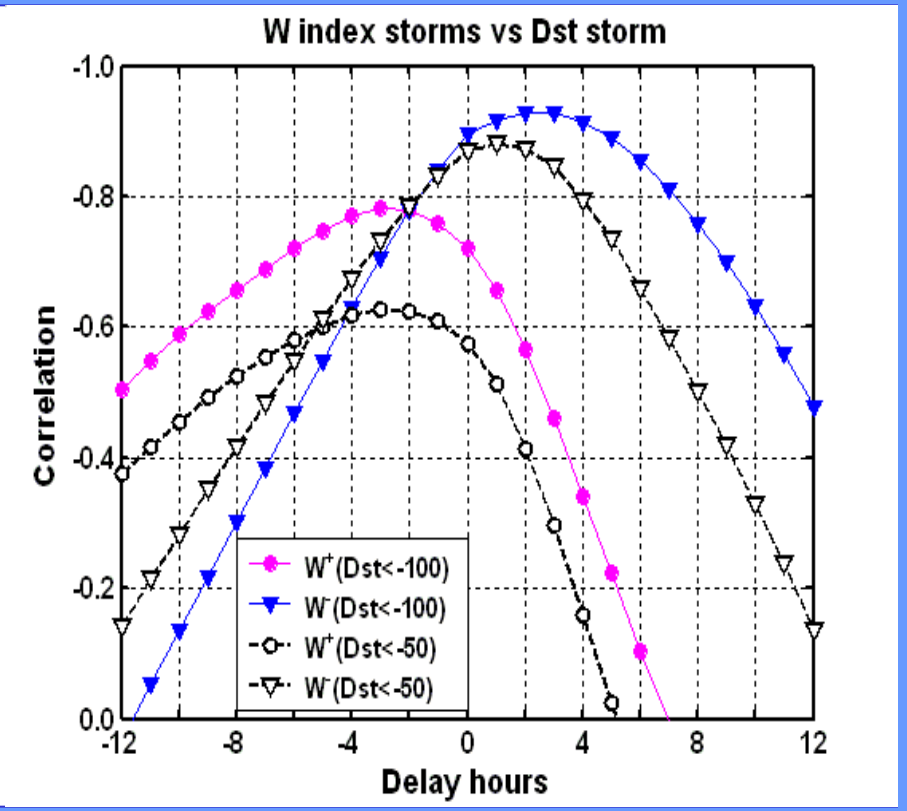
$$z = (x-C)/B;\ x = t+24;\ to-24 < t < to+48\ h,$$

zero time, to, at peak of Dst storm.

The model is based on superposed epoch analysis performed for probability of occurrence per map of the positive ionosphere storms ($W^+ = 3$ and 4) and and negative ionosphere storms ($W^- = -3$ and -4) at 77 intense Dst storms (Dst < -100 nT) and 232 moderate Dst storms (-100 < Dst < -50 nT) during 1999 – 2012.

Time Lag between probability of intense and moderate W^+ ~ Dst storms, and W^- ~ Dst storms





Discussion and Conclusions

- **Global W-index maps and** the planetary index of the ionospheric perturbations, Wp, are produced from GIM-TEC global ionospheric maps for 1999 to present
- Probability of positive ($W^+ = 3$ and 4) and negative ($W^- = -3$ and -4) ionospheric storm occurrence is evaluated from hourly W index maps during 1999 to 2013
- An empirical probability model of W^+ and W^- global TEC storms is derived based on superposed epoch analysis of the ionosphere storms during 77 intense Dst storms and 232 moderate Dst storms occurred.

Discussion and Conclusions (contd.)

- **Evaluation of the probability of positive and negative ionospheric storm occurrence from daily-hourly W index maps presents a 1st step towards their operational application in the terrestrial and space technological systems.**
- **The further progress should be expected in modeling the latitudinal, regional and local characteristics of the of W^+ and W^- index storm probability, specification of local time of the storm onset, an amplitude and duration of each phase of the storm, and their relations to the sources on the Sun, in the interplanetary space and the Earth's magnetosphere.**

Acknowledgements

- **GIM-TEC maps produced by Iono-WG are provided online at *ftp://cddis.gsfc.nasa.gov/pub/gps/products/ionex/*.**
- **The numerical ionosphere maps, indices and Catalogue of the ionosphere-plasmasphere storms are provided at *http://www.izmiran.ru/services/iweather/*, *http://www.ionolab.com***

  http://www.cbk.waw.pl/
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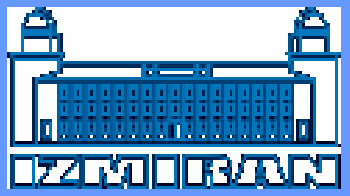

СПАСИБО!

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