Evidence of impact of earthquakes on geomagnetic and ionospheric activity during spotless Sun

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- We investigate the geomagnetic and ionospheric effects of seismic activity during 1810 Sun spotless days (SSL) from 1995 to 2020.
- Catalogue of earthquakes, EQ, is provided by Geophysical Survey, GS-RAS (Obninsk, Russia) at http://www.ceme.gsras.ru/new/eng/ssd_news.htm
- Database of geomagnetic Hpo index [1] is provided by GFZ at https://kp.gfz-potsdam.de/en/hp30-hp60/
- Database of ionospheric GIM-W maps, WU, WL, WE, and Wp indices [2] is provided by IZMIRAN at https://www.izmiran.ru/ionosphere/weather/

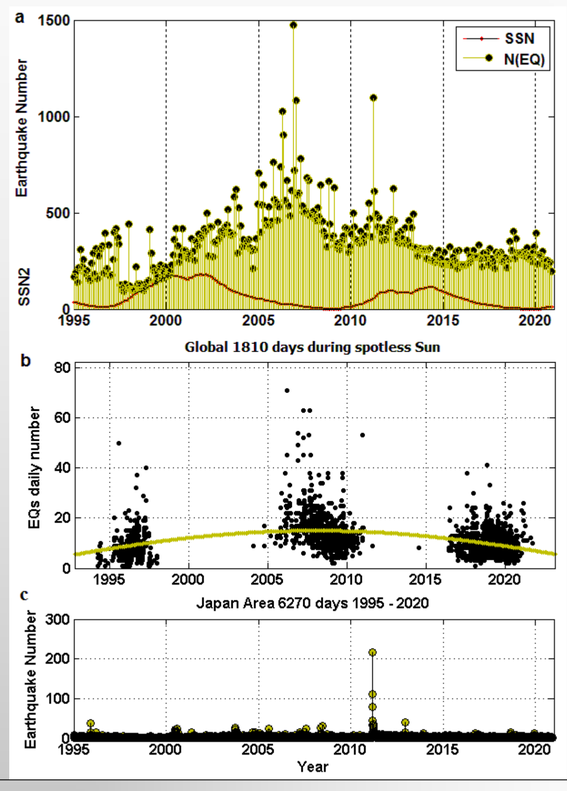

Fig. 1. (a) Monthly number of EQs provided by GS-RAS and smoothed sunspot number SSN2; (b) Daily number of EQs for 1810 spotless days used for the analysis; (c) Daily number of Eqs at Japan area [30-47°N, 134-151°E] observed during 6270 days including 200+ events on 2011.03.11 at Tohoku EQ.

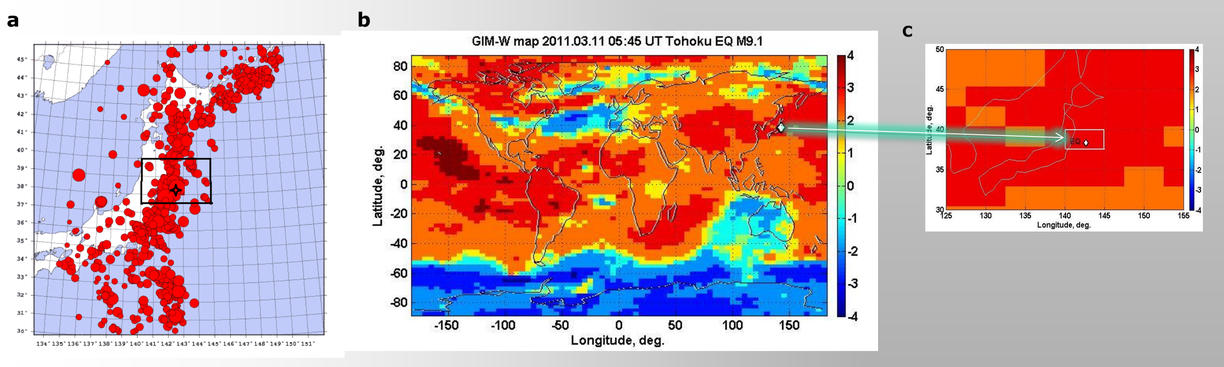

Fig. 2. (a) GS-RAS EQs data at Japan area, including frame of GIM cell (2.5° in latitude, 5° in longitude) around Tohoku EQ; (b) GIM-W(TEC) map at Tohoku EQ 2011.03.11 05:45 UT; (c) GIM cell around Tohoku EQ.

- The ionosphere Weq index is derived at the EQ epicenter from GIM-W map based on JPL GIM-TEC map [3].
- Superposed epoch analysis, SEA, is used with the zero time t_0 taken at EQ from t_0-24h (preEQ) to t_0+24h (postEQ).

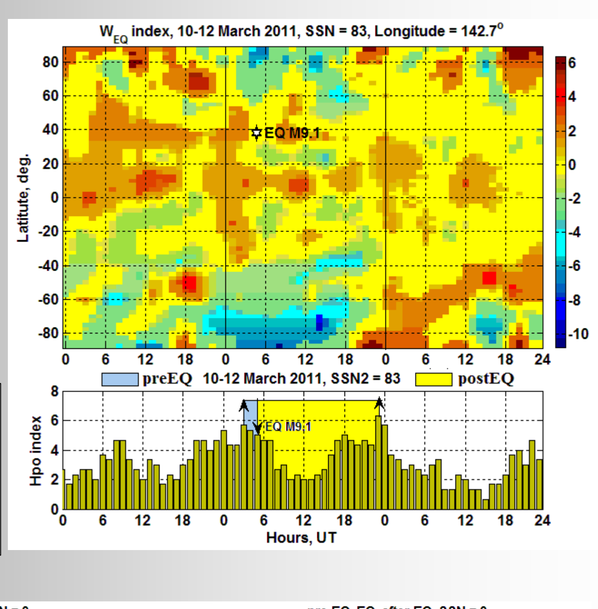

Fig. 3. (a) W index in latitude/time UT frame at 142.7°E during 10-12 March 2011 including Tohoku EQ M9.1 on 2011.03.11 at 05:45 UT; (b) geomagnetic Hpo index exceeding Hpo(t_0) during t_0(EQ) ±24h for preEQ and postEQ time.

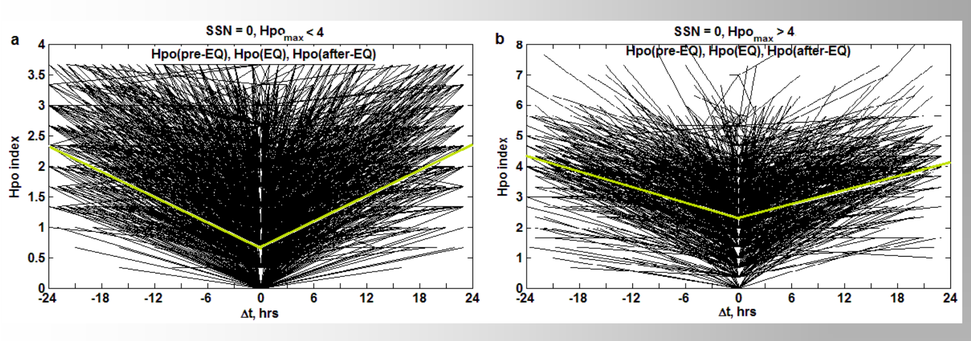

Fig. 4. The results of SEA analysis of Hpo index. (a) Hpo < 4.0 i.u.; (b) Hpo ≥ 4.0 before and/or after EQ.

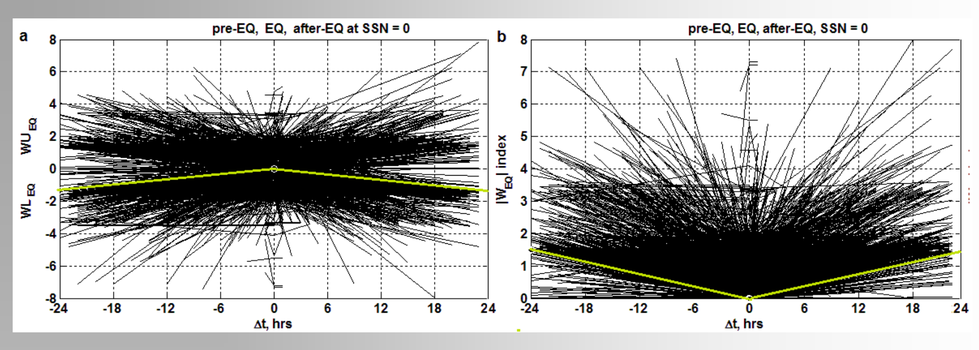

Fig. 5. The results of SEA analysis of W_{EQ} index. (a) positive $WU_{EQ} > 0$ or negative $WL_{EQ} < 0$; (b) absolute $|W_{EQ}|$ index.

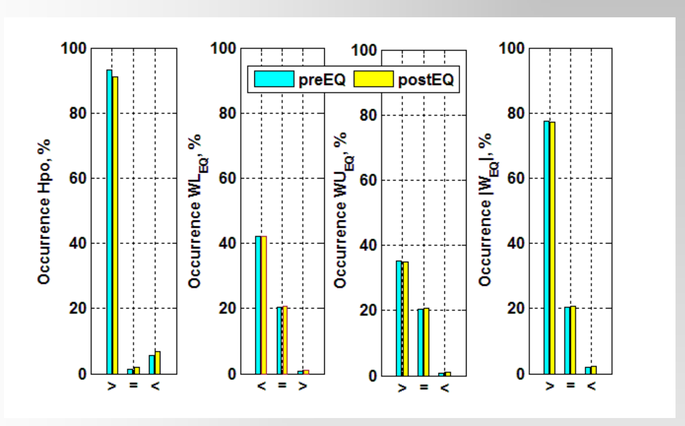

Fig. 6. Histogram of occurrence of relations between Hpo (1st panel), negative WL (2nd panel), positive WU (3rd panel), and absolute value $|W_{EQ}|$ index (4th panel) prior earthquake (blue) and after earthquake (yellow) with the relevant index I at EQ. Sign '>' means I(preEq) > I(t_0) and I(postEQ) > I(t_0); '=' means the index is equal to I(t_0); '<' means that I(preEq) < I(t_0) and I(postEQ) < I(t_0)

Conclusions

- Superposed epoch analysis SEA is made with the zero epoch time $t_0 \pm 24$h taken at daily peak earthquake EQ time for spotless Sun during SC23 and SC24
- Intensity of the local TEC disturbance $|W_{EQ}|$ index at EQ's epicenter is greater prior and after t_0 than that at EQ time t_0 in 77% of events
- The decay of the planetary geomagnetic Hpo index at EQ time t_0 is observed for 91% of cases as compared to Hpo(preEQ) and Hpo(postEQ).
- These results testify on the planetary interplay between the Earth and space environment considering that Hpo index is measured at sub-auroral latitudes while EQs occur at middle and equatorial latitudes [1. 3]

References

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2. Gulyaeva, T.L., Haralambous, H., Stanislawska, I. 2021. Persistent perturbations of ionosphere at diminution of solar and geomagnetic activity during 21-24 solar cycles. J. Atmos. Solar-Terr. Phys., 221, 105706, https://doi.org/10.1016/j.jastp.2021.105706
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