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# EVIDENCE OF IMPACT OF EARTHQUAKES ON GEOMAGNETIC AND IONOSPHERIC ACTIVITY DURING SPOTLESS SUN

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# ***Outline***

- **GS-RAS Database of earthquakes**
- **Database of geomagnetic indices**
- **Database of ionospheric indices**
- **$W_{EQ}$  index of TEC variability at EQ epicenter**
- **Decline of geomagnetic Hpo index and  $W_{EQ}$  index at earthquake**
- **Summary and conclusions**

**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](http://www.ceme.gsras.ru/new/eng/ssd_news.htm)

The screenshot displays the website of the Federal Research Center Russian Academy of Sciences Geophysical Survey. The main navigation bar includes links for News, Catalogs, Wave Forms, EEAS, New, Software, Links, Structure, Publications, Conferences, and About. The 'Last Earthquake' section is highlighted, showing a search by number (200) and date (22.10.2022). Below this is a world map titled 'Last 10 Earthquake' showing earthquake locations with red triangles. To the right, a section titled 'Seismic Catalogues and Bulletin' lists various catalogues and bulletins with corresponding years.

**Seismic Catalogues and Bulletin**

| Bulletins of Teiseismic Stations (FTP) |      |      |      |      |
|--|------|------|------|------|
| 2011                                   | 2007 | 2020 | 2021 | 2019 |
| 2017                                   | 2006 | 2010 | 2018 | 2014 |
| 2008                                   | 2013 | 2016 | 2009 | 2012 |
| 2015                                   |      |      |      |      |

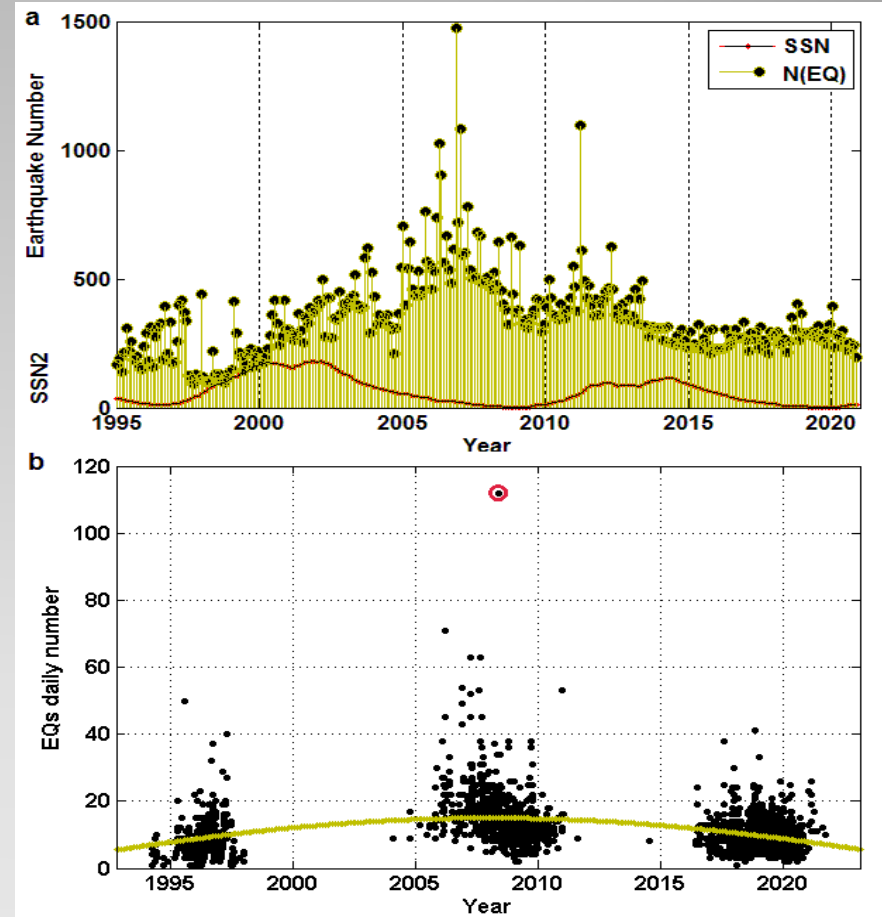
  

| Catalogues of Teiseismic Stations (FTP) |      |      |          |      |
|---|------|------|----------|------|
| 2011                                    | 2007 | 2020 | 2021     | 2019 |
| 1999                                    | 1995 | 2017 | 2006     | 2010 |
| 2018                                    | 2005 | 2014 | 2008     | 2000 |
| 2001                                    | 2013 | 2004 | 1994.txt | 2002 |
| 2016                                    | 1997 | 2009 | 2003     | 1998 |
| 1993.txt                                | 1996 | 2012 | 2015     |      |

# GS-RAS Earthquake database

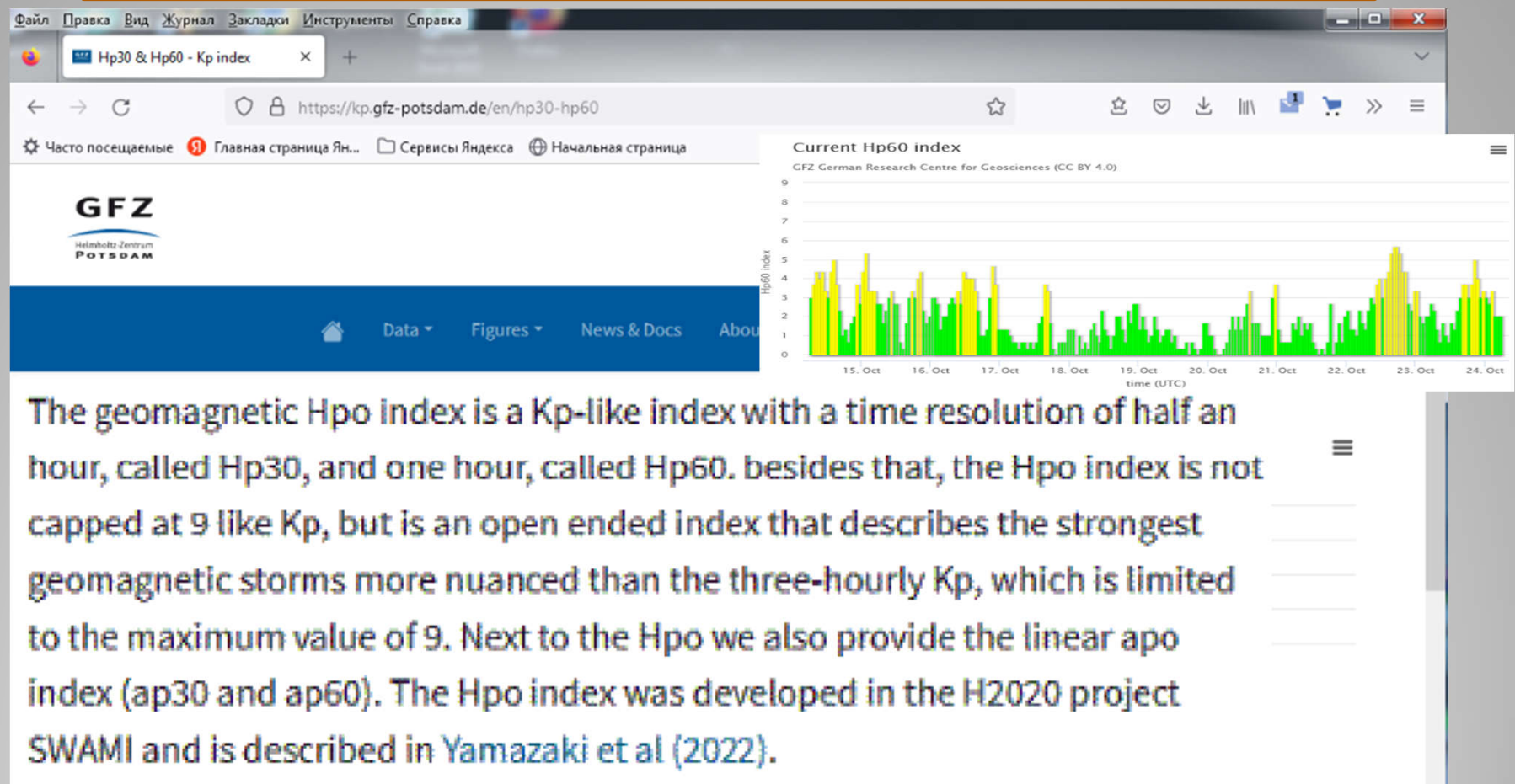
**(a)** Monthly number of EQs provided by GS-RAS and the 12-month smoothed sunspot number SSN2

**(b)** Daily number of EQs and fitting curve for the Sun spotless days used for the analysis from 1995 to 2020.



**GS-RAS Earthquake database:  
Seismic activity is growing  
towards the solar minimum**

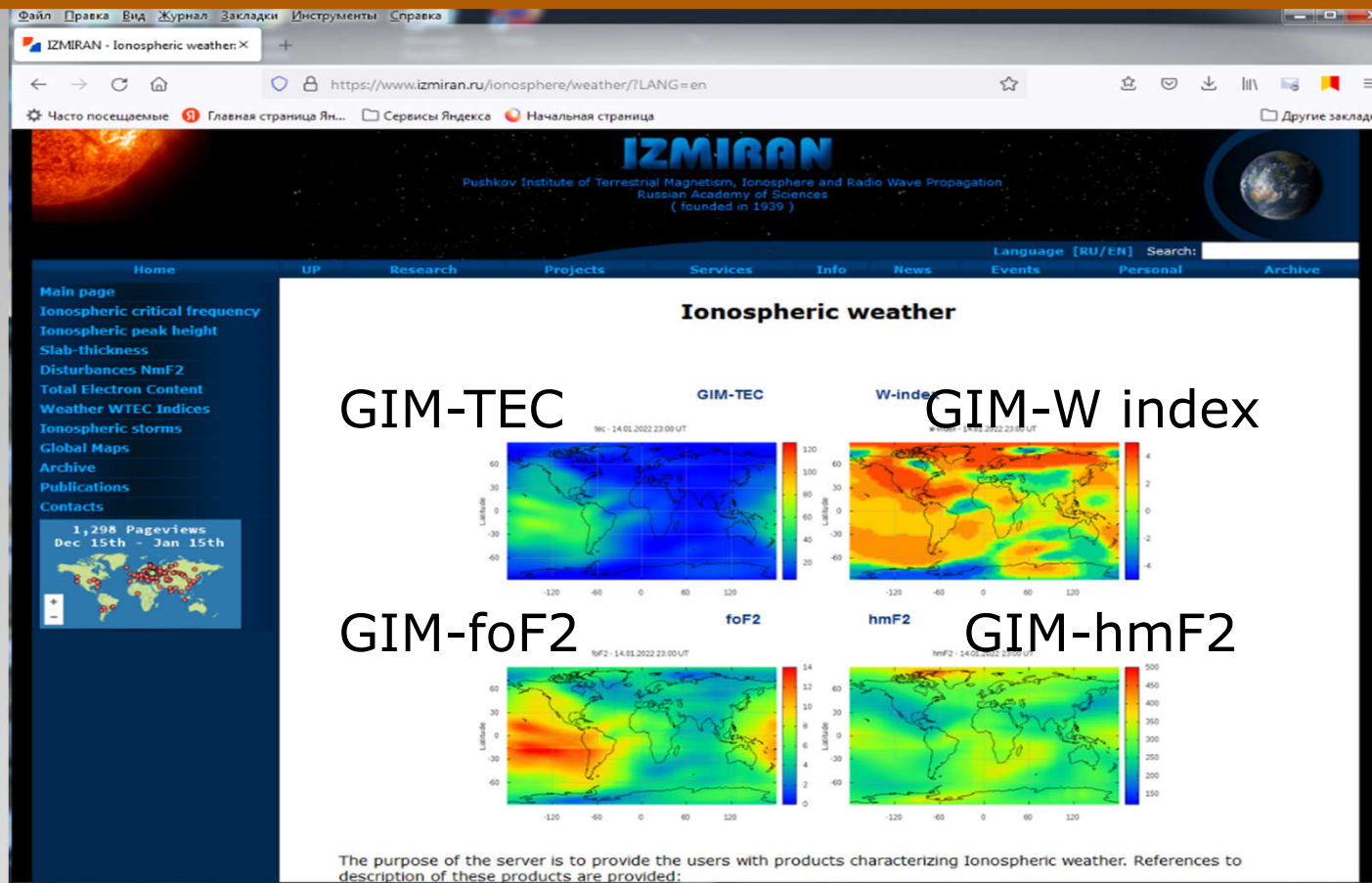
<https://kp.gfz-potsdam.de/en/hp30-hp60/>



**Database of geomagnetic indices:  
Kp, Ap, Hpo indices from 1995 to present**

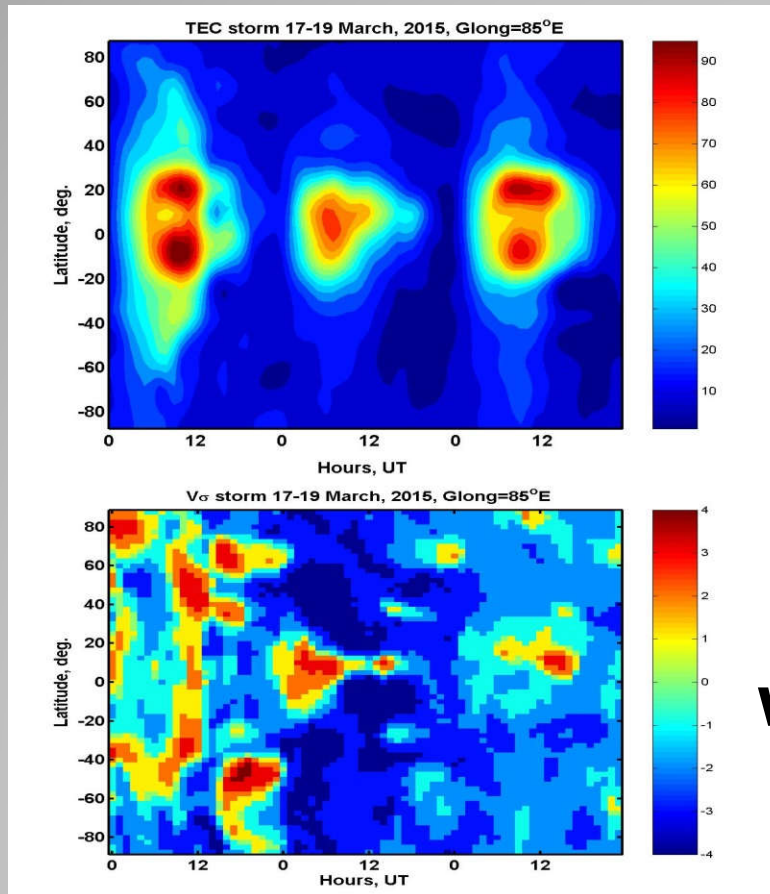


<https://www.izmiran.ru/ionosphere/weather/>



**Database of ionospheric indices:  
Archive of GIM-W maps, WU, WL, WE, Wp  
indices from 1994 to present**

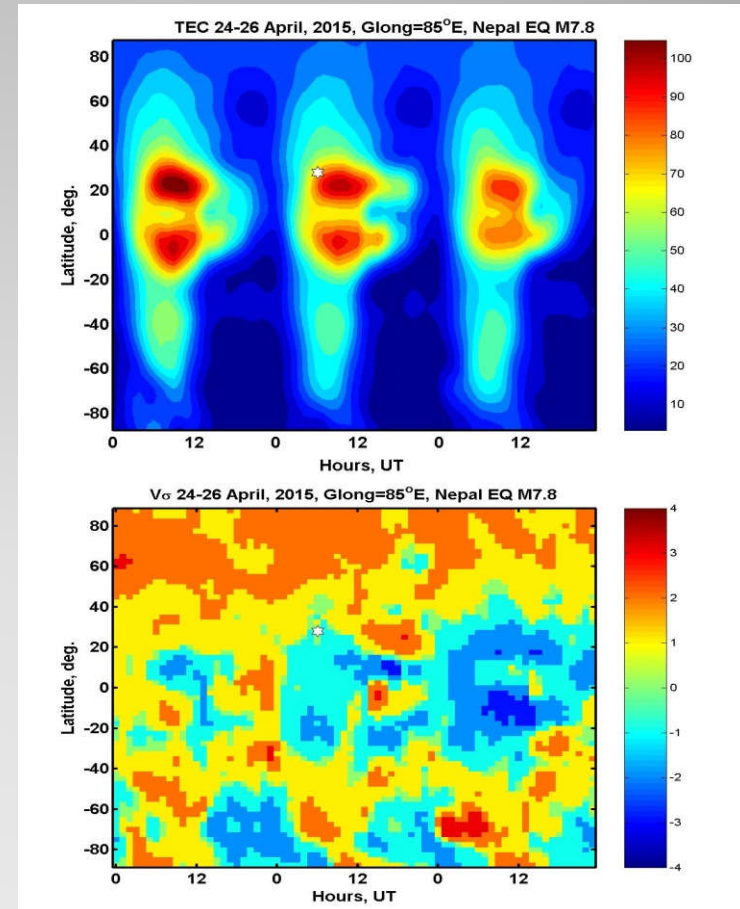
## Storm 17-19 Mar 2015



TEC

W(TEC)

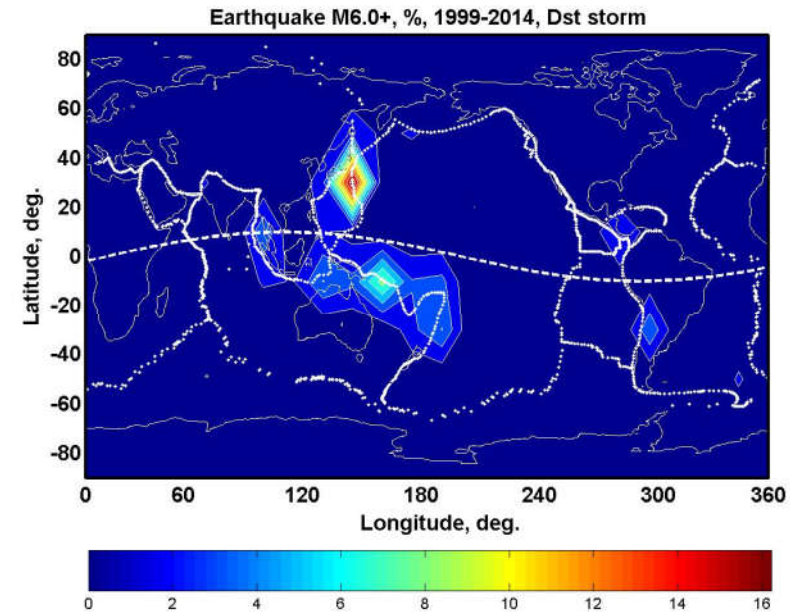
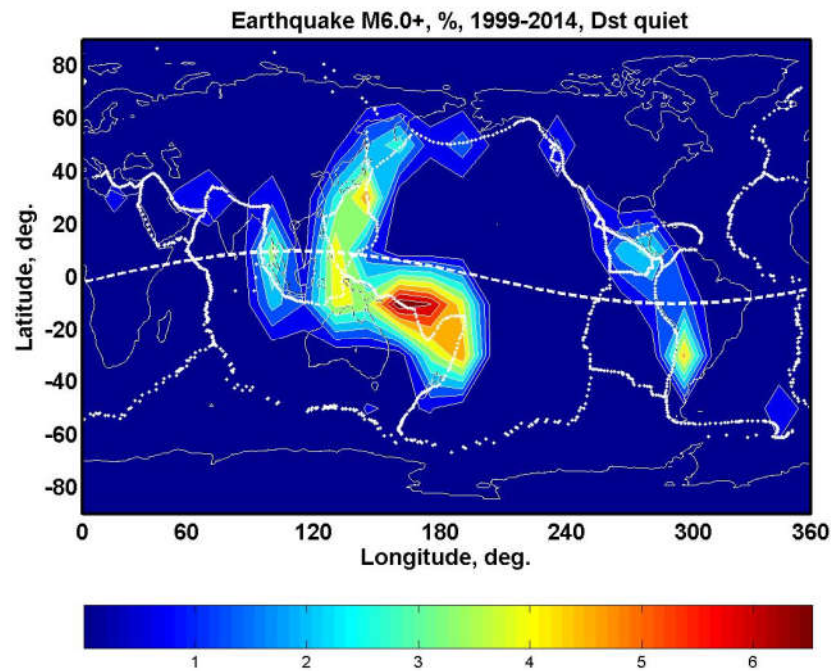
## Nepal EQ M7.8 24-26 Apr 2015



**Different effects of geo-storm and EQ on TEC and W(TEC) at 85°E meridian**

**EQs data provided by NCEDC  
(doi:10.7932/NCEDC)**

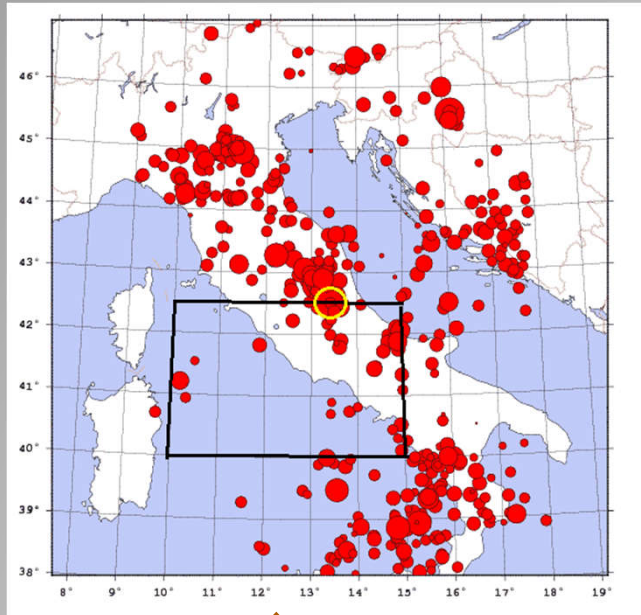
**EQs at geo-storms 1999-2014**



**Eqs M6+ under quiet conditions**

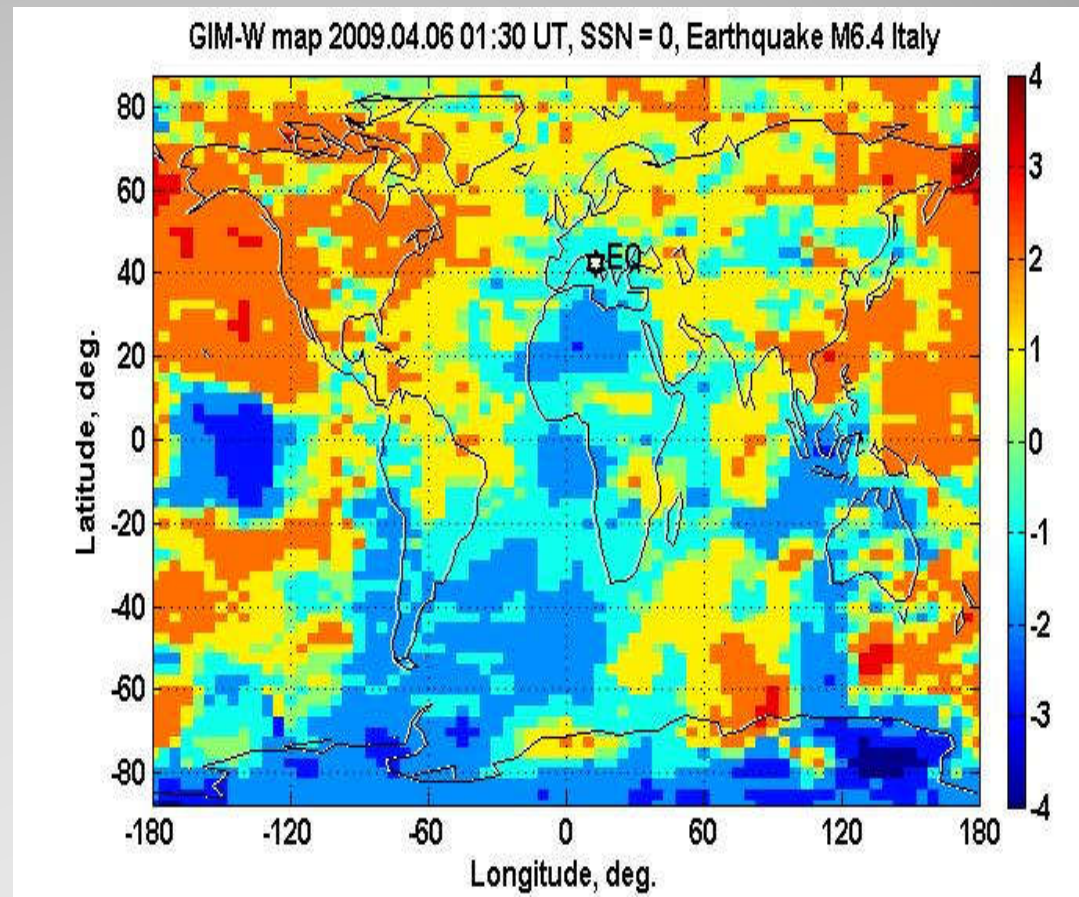
**Zones of enhanced seismic activity  
under quiet space weather and  
geomagnetic storms**

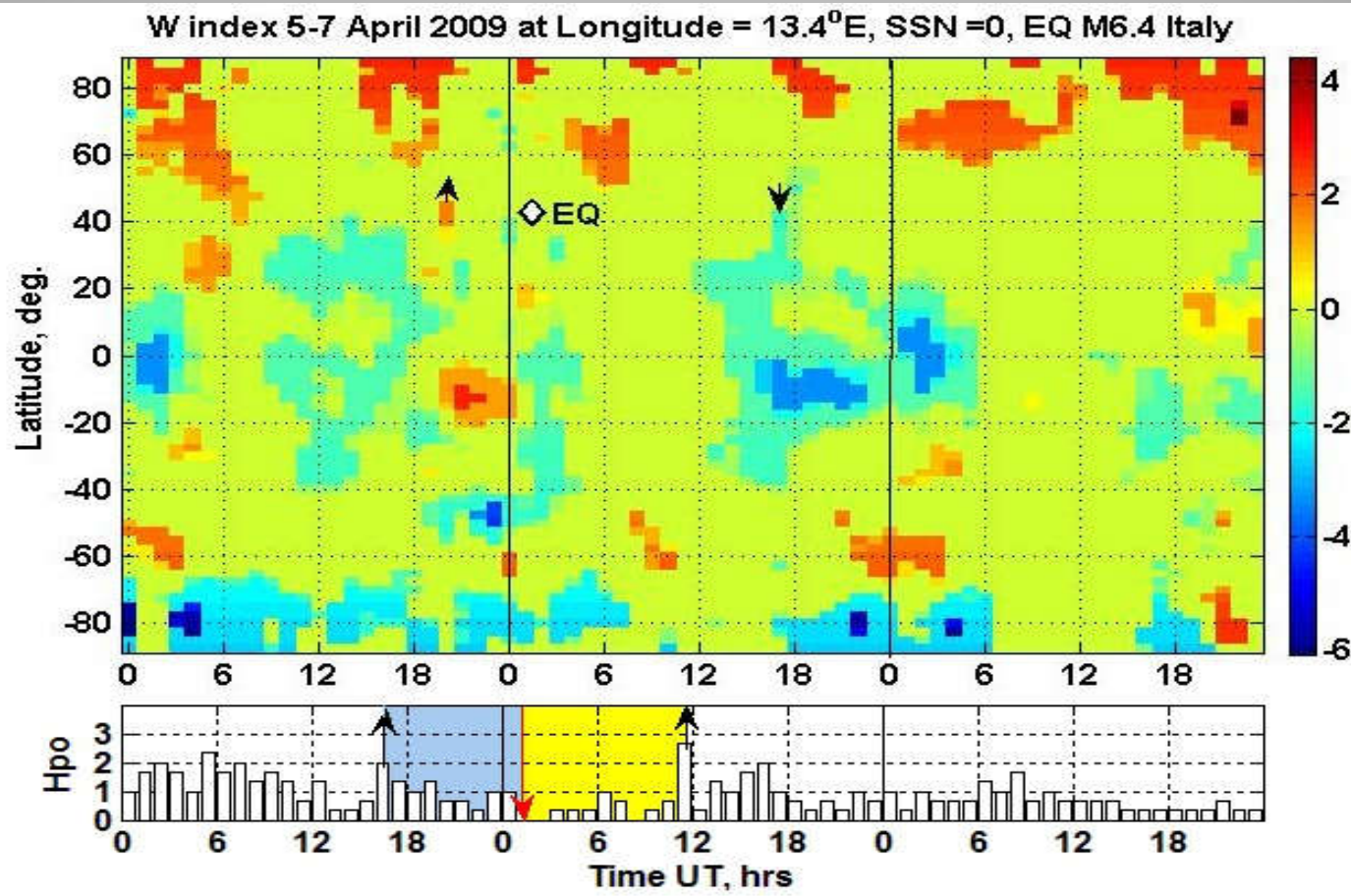




**Cell 2.5°x5° in latitude & longitude used to calculate  $W_{EQ}$  index at EQ epicenter (M6.4, Italy, 7.04.2009 01:30 UT**

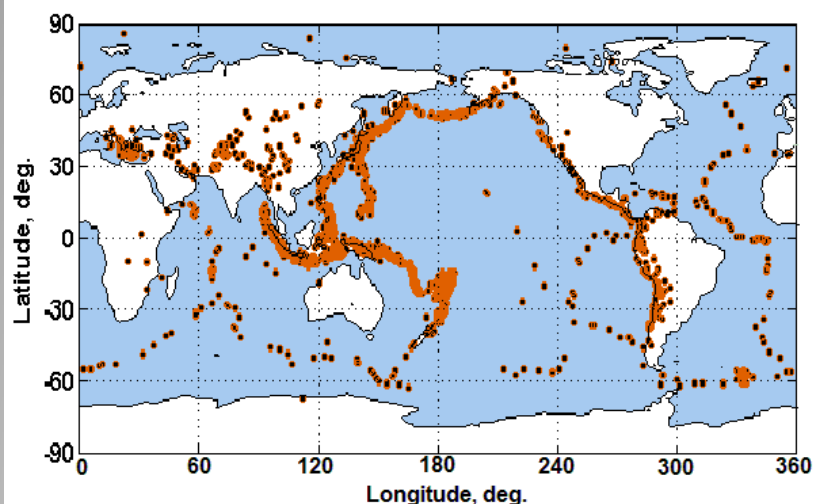
**GS-RAS Collection of 500+ earthquakes over Italy and W(TEC) map including EQ M6.4, on 7.04.2009, 01:30 UT, at SSN = 0**





**W(TEC) at longitude 13.4°E 6-8 April 2009 including EQ M6.4, Italy, 7.04.2009, SSN=0.**  
**Bottom: geomagnetic Hpo index growing at  $t_0(\text{EQ}) \pm 24$  h of preEQ and postEQ time**

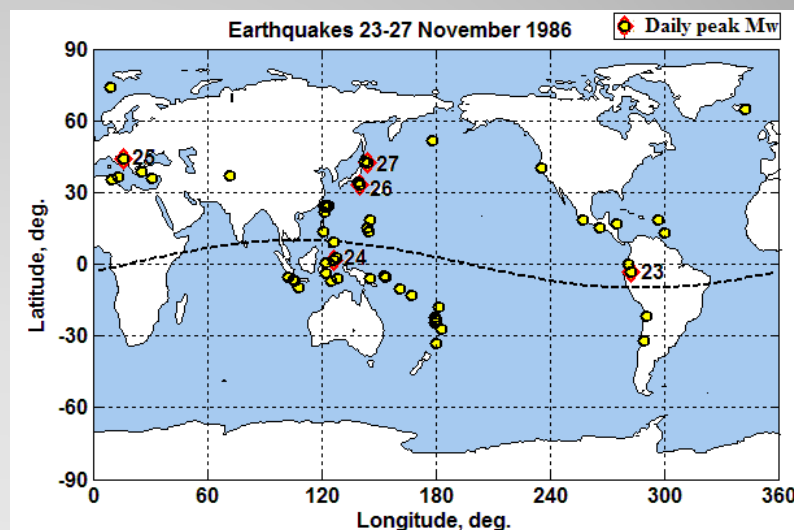
**a**



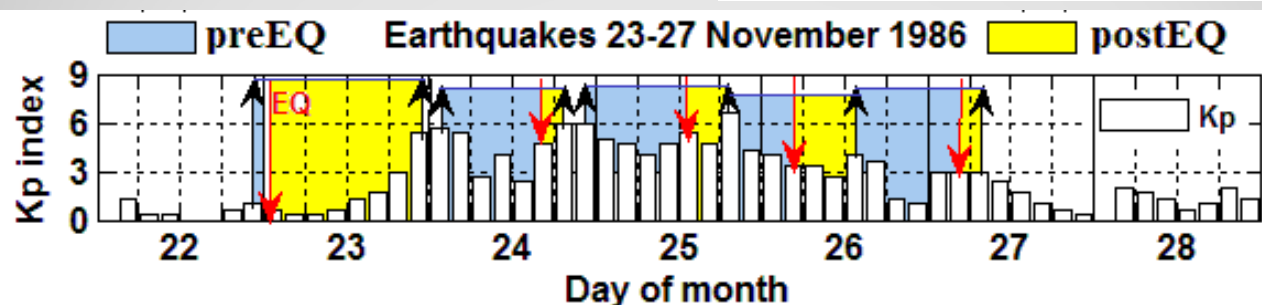
**EQ data provided by GS-RAS**

**EQ data provided by NCEDC  
(doi:10.7932/NCEDC)**

**b**

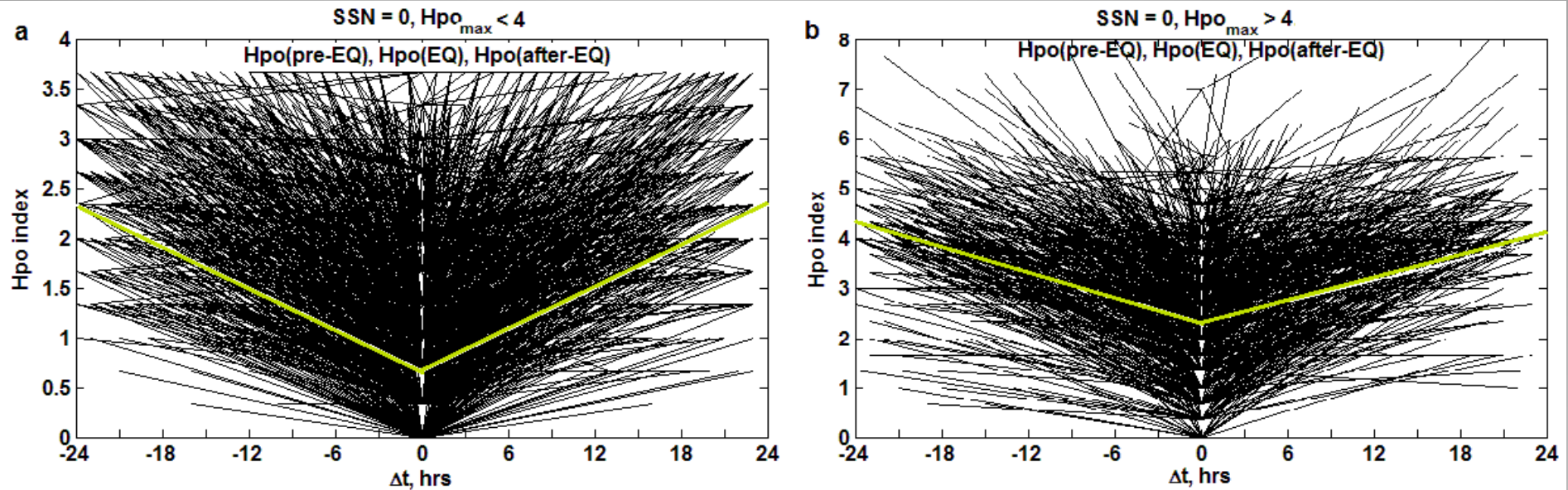


**c**

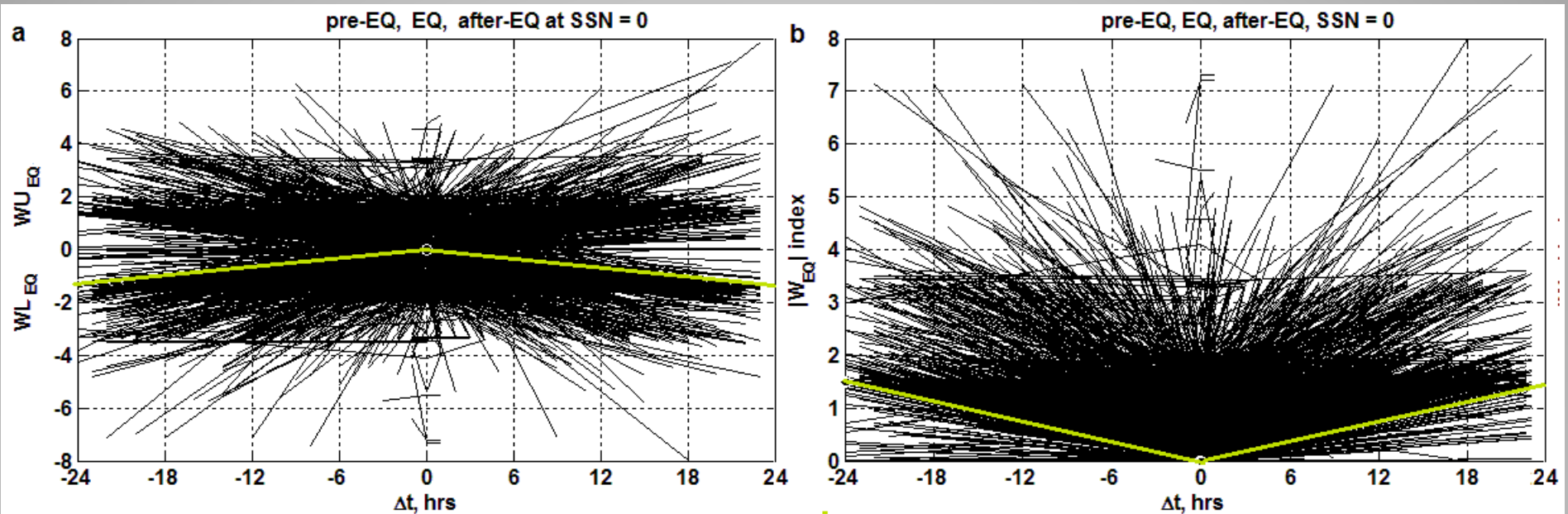


**(a)EQs total set at SSN=0; (b) EQs on 23-27.11.1986; (c) Kp index is dropped down at daily peak EQ**



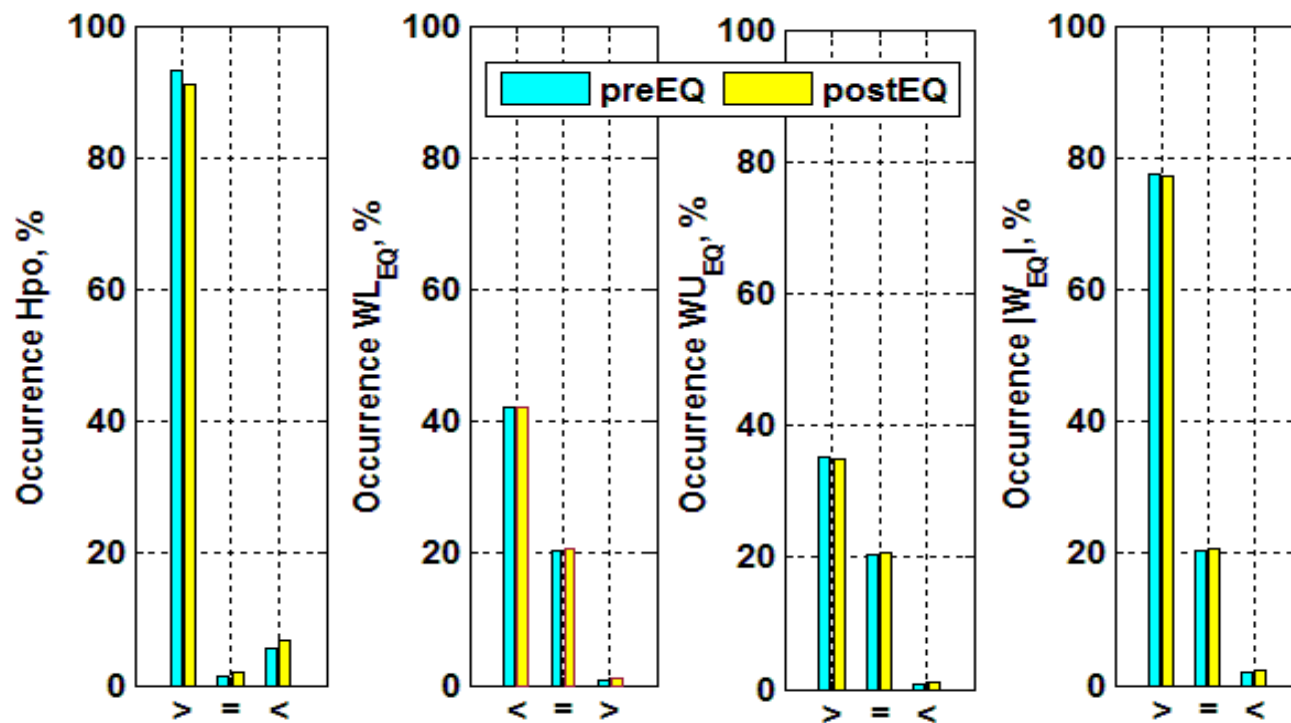


**The results of superposed effects analysis (SEA) of Hpo index. (a)  $Hpo < 4.0$  i.u.; (b)  $Hpo \geq 4.0$  before and/or after EQ.**



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





**Occurrence of relations between Hpo, WL, WU and  $|W_{EQ}|$  index value prior earthquake and after earthquake with index value at EQ**

- We investigate the geomagnetic and ionospheric effects of seismic activity during 1810 Sun spotless days (SSL) from 1995 to 2020.
- Newly developed 1h geomagnetic index Hpo and the ionospheric Weq index are used for the comparisons with the daily peak earthquake Mw.
- The ionosphere Weq index is derived at the EQ epicenter from GIM-W map based on JPL GIM-TEC map.

## Conclusions-1

- Superposed epoch analysis is used with the zero epoch time  $t_0$  taken at EQ.
- It is found that the magnitude of  $H_{po}(t_0)$  is less than the both peaks of  $H_{po}(\text{preEQ})$  and  $H_{po}(\text{afterEQ})$  in 91% of EQs.
- Similar effect is observed in 71% of events with the peak of the absolute values of  $|W(\text{preEQ})|$  and  $|W(\text{afterEQ})|$  the both exceeding  $|W_{eq}|$ .
- Our results provide evidence that EQ-related geomagnetic and ionospheric activities experience decline of intensity at the time of EQ during SSL.

## Conclusions-2

# Thank You!