

# Exploring Local Geomagnetic Variations in Taiwan from Historical Data for Space Weather Understanding

Huei-Wen Siao<sup>1,2</sup>, I-Te Lee<sup>3</sup>, Po-Han Lee<sup>1,2</sup>, Jia-Sin Kuo<sup>4</sup>, Chih-Hsuan Li<sup>4</sup>, Jing-Shan Hong<sup>1</sup>

<sup>1</sup>Central Weather Administration, Taiwan; <sup>2</sup>Taiwan Group on Earth Observations, Taiwan;

<sup>3</sup>Taiwan Space Agency, Taiwan; <sup>4</sup>Department of Space Science and Engineering, National Central University, Taiwan

## Motivation

Geomagnetic field sometimes exhibits variations ranging from tens to hundreds of nanoteslas which influenced by various sources. This study reviews local geomagnetic field variations in Taiwan from 1965 to the present (solar cycles 20 to 25), aiming to identify possible local geomagnetic influences and serves as a reference for evaluating the local impact of space weather.

## Data and Methodology

- Jul. 1965 – Dec. 2000**  
**Lunping Observatory (LNP)**
  - Jul. 1965 – Dec. 1993  
Digitization of original geomagnetic field records booklets
  - Dec. 1993 – Dec. 2000  
From WDC for Geomagnetism
- Nov. 2002 – Oct. 2005**  
**National Central University (NCU)**
  - Nov. 2002 – Jul. 2005  
GSM90F Scalar Magnetometers
- Jan. 2007 – Now**  
**Taiwan Geophysical Networks for Seismology (TGNS), CWA**
  - Jan. 2007 – Dec. 2019  
GSM90F Scalar Magnetometers
  - Dec. 2019 – Now  
FRG-604RC Fluxgate Magnetometers

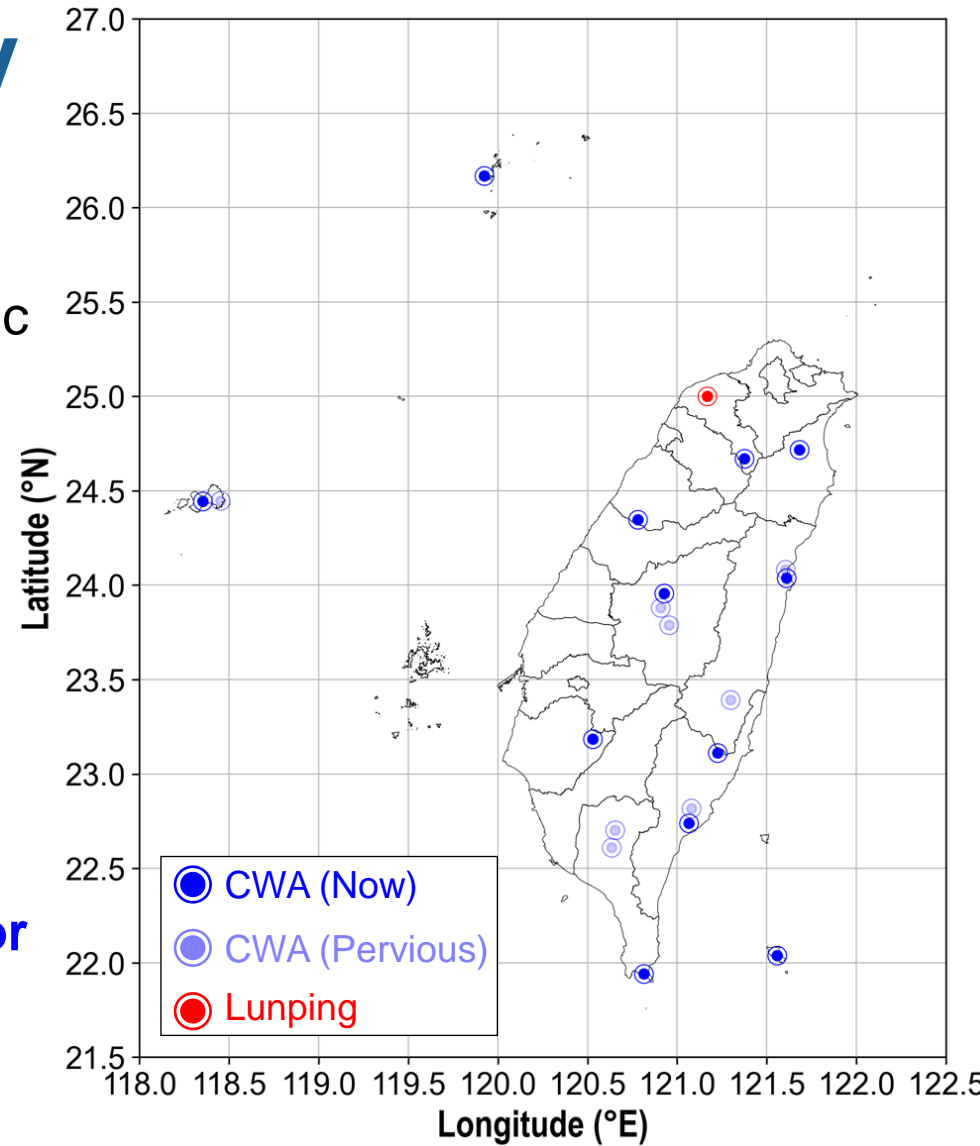


Figure 1. Location for Taiwan geomagnetic observatories started from 1965.

## 1. Selection of Quiet Days

Defining quiet days is to use the ten International Quiet Days (IQDs) from WDC for Geomagnetism.

## 2. Determination of Baselines

- Nighttime baseline  $H_0$   

$$H_0 = \frac{H_{23} + H_{24} + H_{01} + H_{02}}{4}$$
,  $H_{LT}$ : H component with LT
- $\Delta H_t = H_t - H_0$
- non-cyclic variation  $\Delta c$   

$$\Delta c = \frac{\Delta H_{01} - \Delta H_{24}}{23}$$

## Solar quiet variations (Sq(H))

$$Sq(H)_t = \Delta H_t + (t - 1)\Delta c$$

## Taiwan disturbance index (TWDI)

Disturbance index is estimated by local magnetometer.

## Results

### Sq variation

#### Daily Variation

Sq(H) is mainly positive, with peak values typically occurring between 01:00 and 07:00 UT, corresponding to the morning and afternoon local periods in Taiwan.

#### Solar Cycle Variation

Our analysis shows that the monthly maximum of daily Sq(H) correlates with the yearly average of the sunspot number. However, the magnitude of Sq(H) during 1965 to 2000 observed by LNP was smaller than that observed by CWA and NCU from 2002 to 2024.

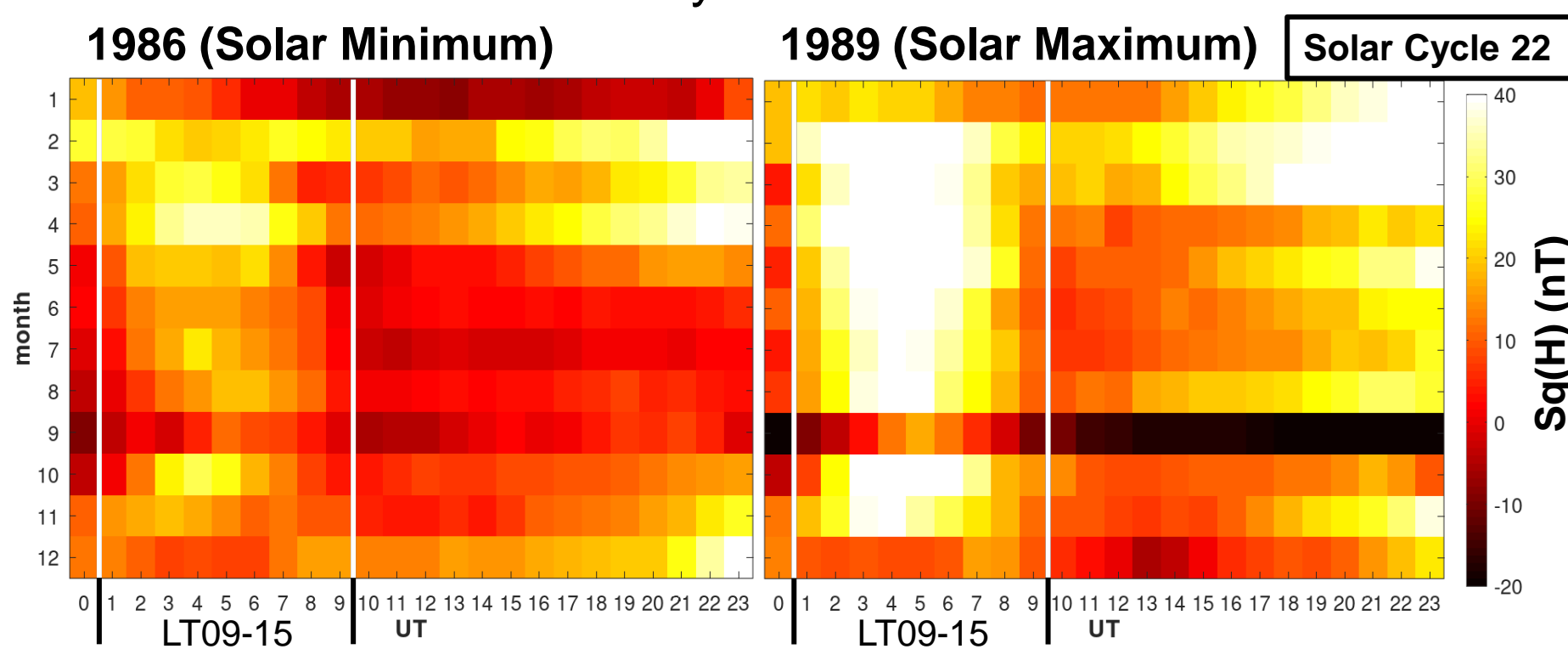


Figure 2. Daily variation of Sq(H) for solar minimum (1986) and solar maximum (1989).

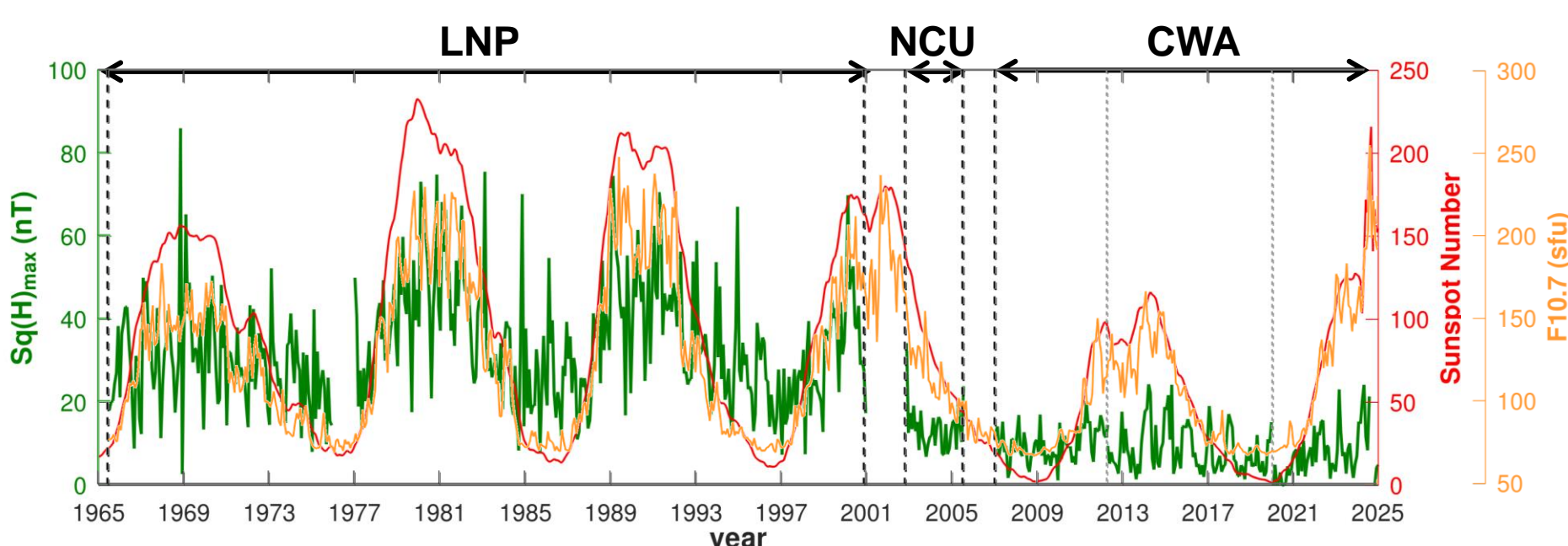


Figure 3. The monthly maximum of daily Sq(H) along with sunspot number. The green line is monthly maximum of daily Sq(H). The red line is 13-month smoothed monthly total sunspot number.

### Geomagnetic Storm

According to Figure 4, the variation of TWDI is similar with Dst index during geomagnetic storms.

Table 1. Dst Index, TWDI, and Their Differences for Large-Scale Geomagnetic Storms

Disturbance Storm index (nT)	Dst	TWDI	Dst-TWDI
MAR 1989 G5 storm	-589	-571.70	17.3
OCT 2003 <sup>a</sup> G5 storm	-353	-307.79	45.21
OCT 2003 <sup>b</sup> G5 storm	-383	-382.83	0.17
MAY 2024 G5 storm	-412	-485.39	73.39
OCT 2024 G4 storm	-333	-395.73	62.73

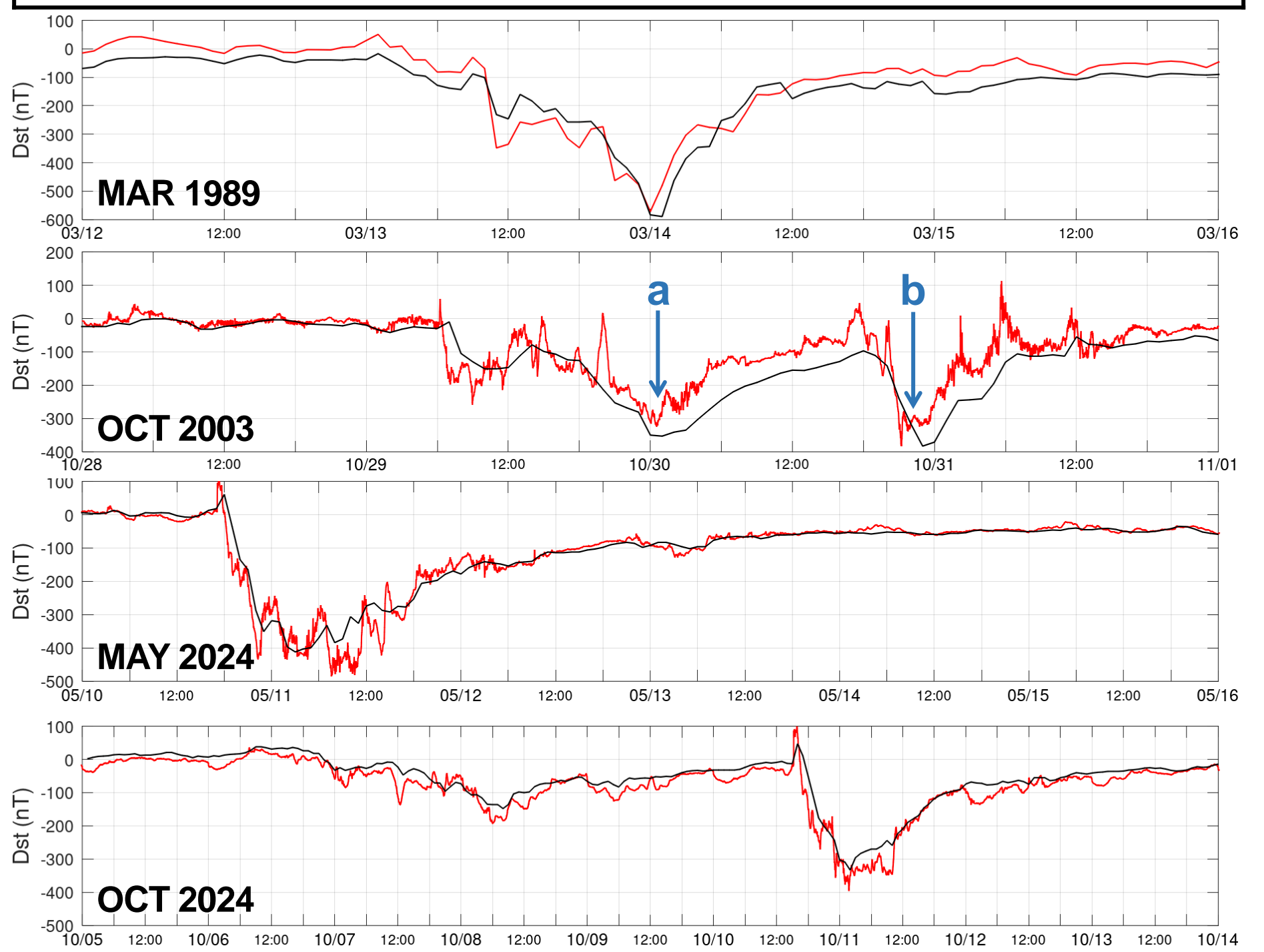


Figure 4. TWDI and Dst index for two significant geomagnetic storm. The red line represents TWDI, while the black line represents Dst index.

## Summary

- The properties of Sq variation are roughly consistent with theoretical results. However, the varying magnitudes observed in different observations would require further investigation.
- Due to the local impact of geomagnetic storms, TWDI shows finer variations, capturing more detailed fluctuations at a higher temporal resolution.

## References and Acknowledgements

- M. Takeda (2013b), *Space Phys.* **118**, 4516–4522.
- Messanga Etoundi Honoré *et al.* (2017) *International Journal of Geosciences*, **8** 4.
- Yamazaki, Y. & A. Maute. (2017), *Space Sci Rev* **206**, 299–405.
- The sunspot number data is provided by WDC-SILSO, Royal Observatory of Belgium, Brussels.
- The Dst index is provided by WDC for Geomagnetism, Kyoto.

