



Operational Space Weather Monitoring and Forecasting in Taiwan

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Taiwan's geographic location subjects it to the influence of the Equatorial Ionization Anomaly, where rapid plasma density variations, plasma bubbles, and irregularities severely impact high-frequency and satellite communications, as well as navigation systems. To address these challenges, the Central Weather Administration (CWA) has collaborated with the Taiwan Space Agency and domestic research teams since 2013 to provide real-time space weather monitoring and forecasts. Currently, CWA operates a range of observational systems, including solar images in visible light, H-alpha, and Calcium K-Line, along with sunspot drawings for sunspot number estimation. In addition, ionograms, real-time global and regional total electron content (TEC) data, scintillation indices, rate of TEC variations, and ionospheric radio occultation profiles provide valuable insights into ionospheric behavior. CWA also runs the Global Ionospheric Specification, which generates 3D electron density structures for the ionosphere. Meanwhile, the Taiwan Disturbance Index is computed to assess geomagnetic disturbances in the Taiwan region. To enhance space weather awareness, CWA issues forecasts daily at 10:00 and 16:00 (local time), with automated reports triggered by space weather events and special warnings issued for severe disturbances. These forecasts and alerts are publicly accessible via the Space Weather Operational Office website, which recorded approximately 470,000 page views and 55,000 users in 2024. Over 1,600 updates were provided throughout the year, including both automated event reports and manually updated space weather summaries and forecasts. Further details on these CWA products will be presented and discussed.



SWx Observations, Products, and Services

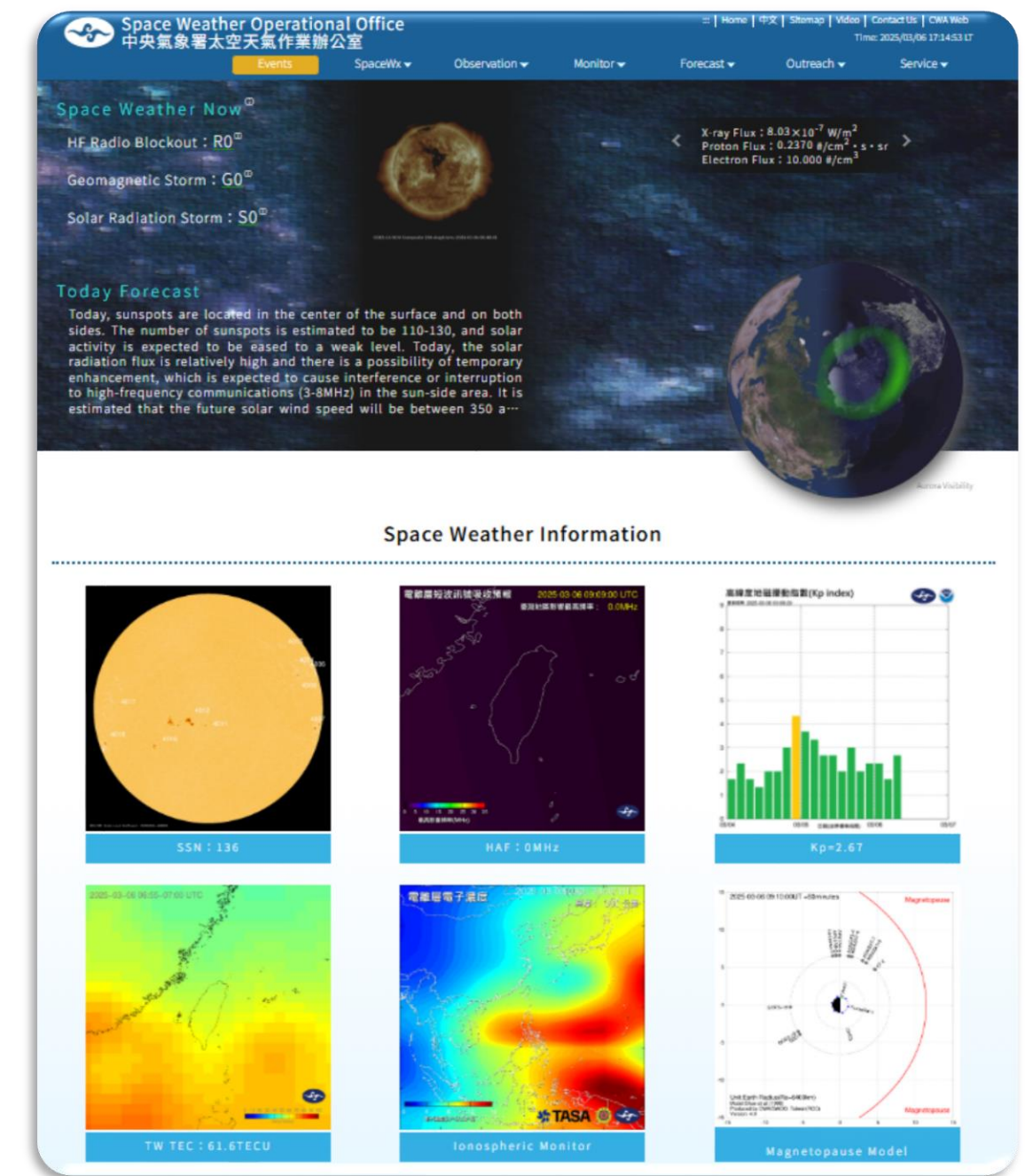
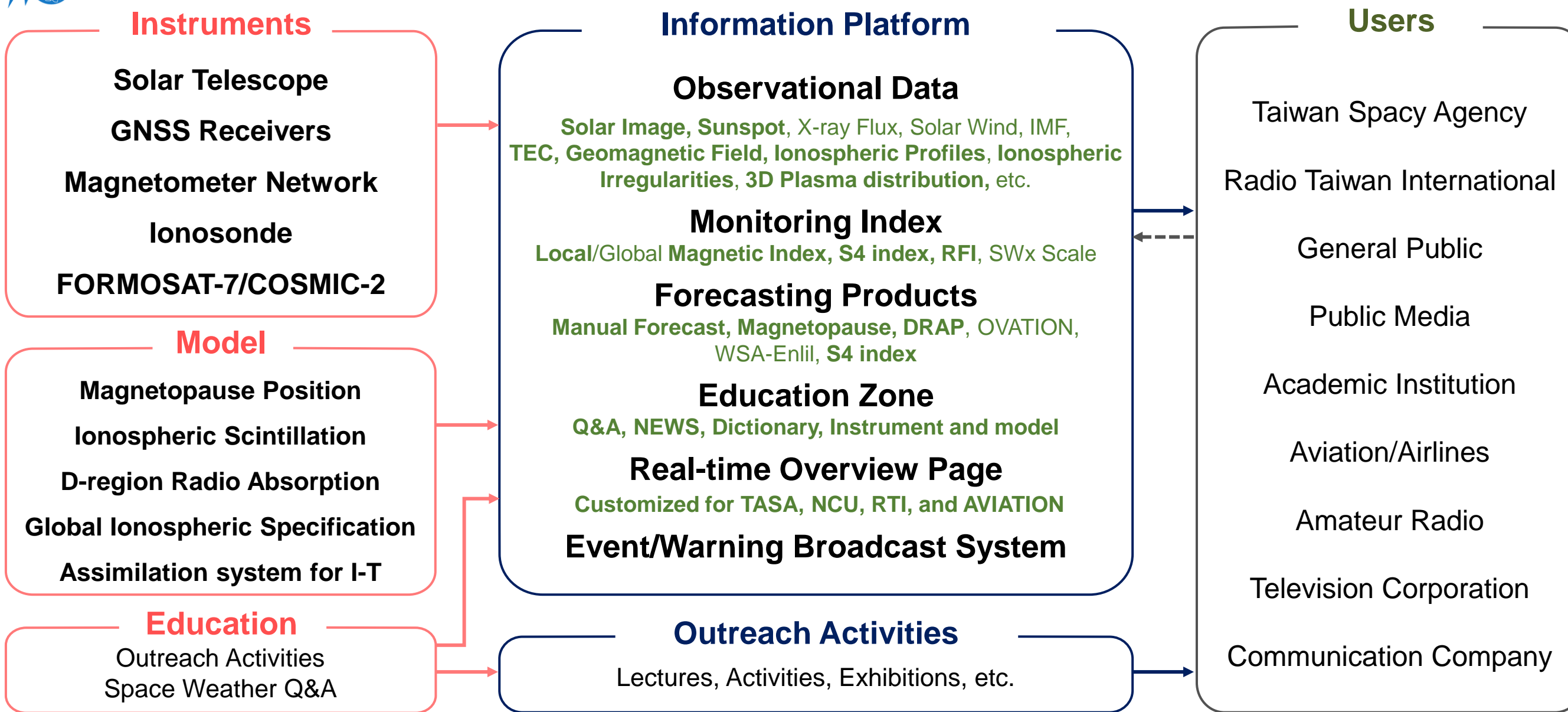


Fig. Website of the space weather service in CWA.



Regional Ionospheric Irregularity Monitoring

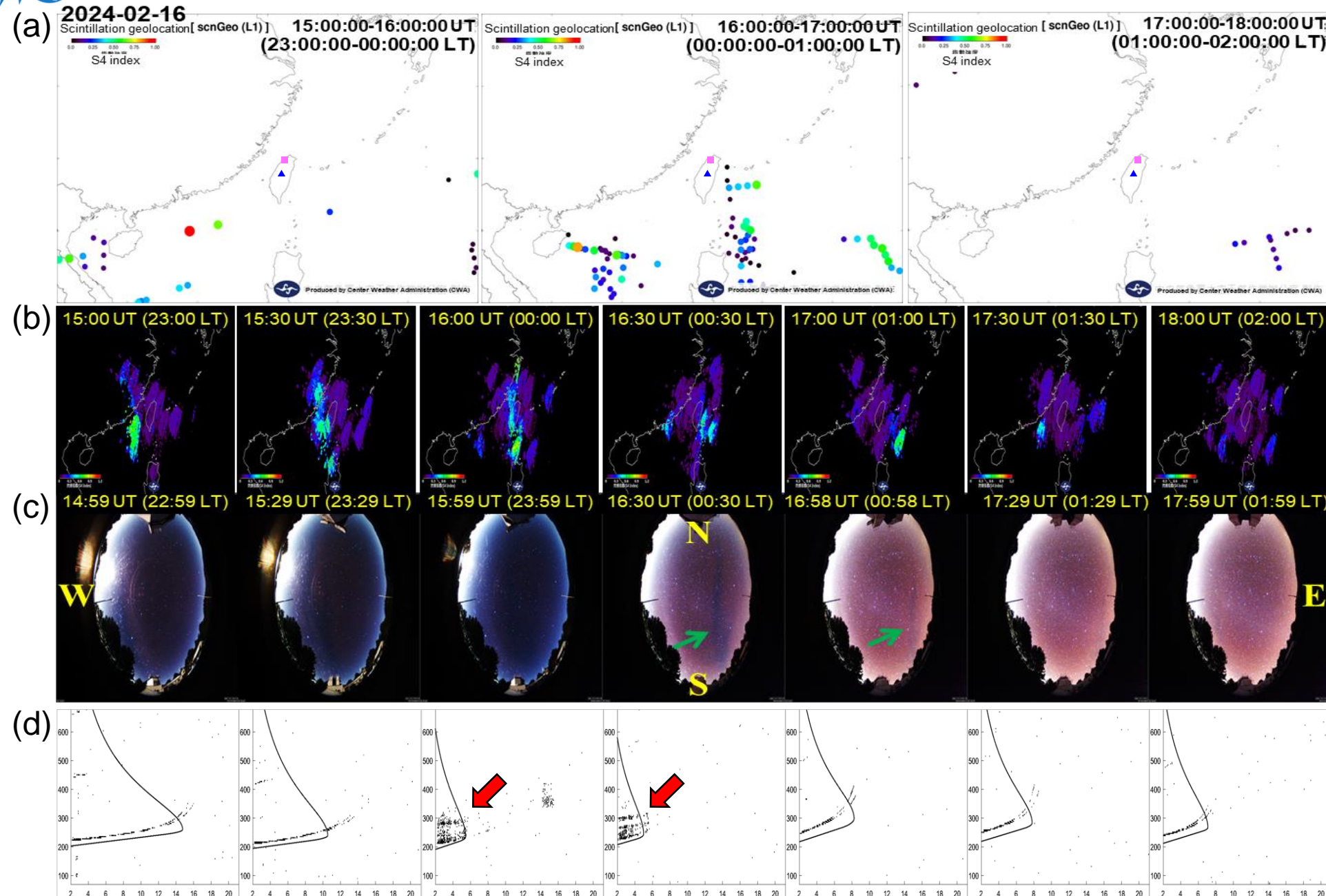


Fig. Observations of (a) F7/C2 scnGeo, (b) the S4 index from Taiwan GNSS ground stations, (c) the all-sky imager at Lulin Observatory (blue triangle in (a)), and (d) ionograms at Xinwu (magenta square in (a)) from 15:00 to 18:00 UT on 16 February 2024. The F7/C2 scnGeo data show a consistently high S4 index over the Taiwan region throughout this period, with disturbances propagating from west to east. Meanwhile, strong S4 index signals detected by GNSS ground stations exhibit a distinct southwest-to-east propagation pattern. The all-sky imager reveals dark regions in the southeast at 16:30 and 16:58 UT, indicated by green arrows and suggestive of plasma bubbles. Observations between 14:59 and 15:59 UT were affected by moonlight interference. Additionally, Spread F signatures, indicated by red arrows, are observed in ionograms at 16:00 and 16:30 UT.



Local Geomagnetic Disturbance Index

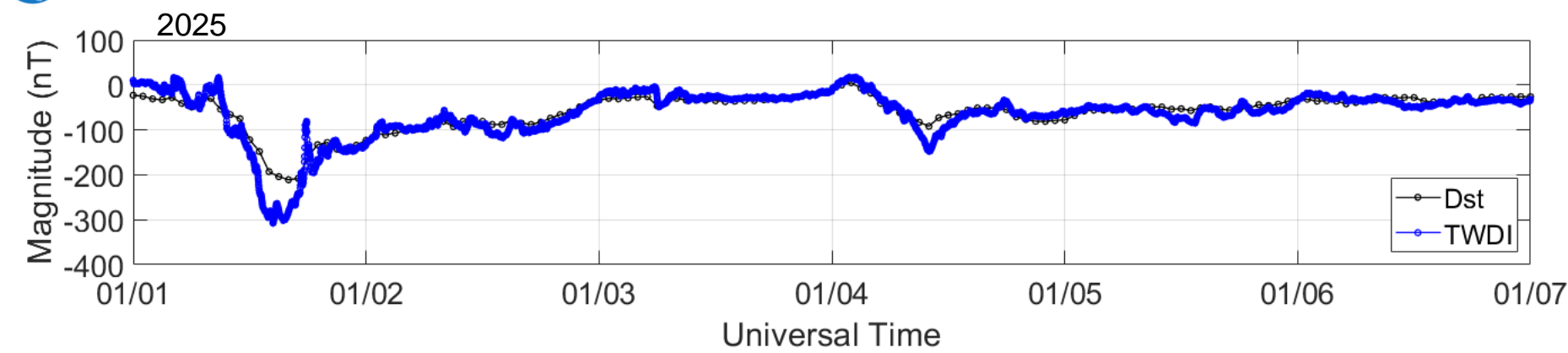


Fig. Comparison of the Disturbance Storm Time (Dst) index and the Taiwan Disturbance Index (TWDI) from 1 to 7 January 2025. The Dst index (black line with circles) represents global geomagnetic storm activity, while TWDI (blue line) reflects local geomagnetic disturbances in the Taiwan region. A G4 (Severe) geomagnetic storm occurred on January 1–2, during which TWDI exhibited stronger fluctuations than Dst, highlighting localized geomagnetic variations.



Daily Space Weather Review and Forecast

Daily Space Weather Overview

Solar Image: Sunspot: 102, SW Speed: 584.1 km/s

Review: Today's sunspots are located in the center of the surface and on both sides with the number of sunspots being 102 and solar activity belongs to the level of M4.5. The solar radiation flux was relatively high during temporary interference or interruption to high-frequency (3-30MHz) communication in the sun-side area. However, the solar wind density changed significantly with the maximum wind speed reaching 575 km/s and the geomagnetic disturbance reached a weak magnetic storm level (the maximum Kp value is 6).

Forecast: Today's sunspots are located in the center of the surface and on both sides. The number of sunspots is estimated to be 80-100 and solar activity is expected to be M3.0. The solar radiation flux is relatively high and there is a possibility of temporary enhancement, which is expected to cause interference or interruption to high-frequency communications (3-30MHz) in the sun-side area. It is estimated that the future solar wind speed will be between 350-450 km/s.

SWx Scale Forecast

Geomagnetic Storm: 1	Radio Blackout: 0
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Issued by Central Weather Administration, Taiwan | Data: SWPC/NOAA - CWA | Update: 2025-03-10 10:00:00 (LT)

Fig. Daily space weather overview issued by CWA on 10 March 2025. The overviews include textual descriptions of the daily review and forecast, along with solar images, sunspot numbers, solar wind speed, X-ray flux, the Kp index, ionospheric HF absorption, and space weather scales. These overviews are updated twice a day, seven days a week.



Ionosphere and Thermosphere Forecasting with Assimilated Model

System:

- Ensemble Kalman Filter with 48 members
- Spatial resolution: 2.5° x 2.5° x 0.25 plev
- Temporal resolution: 60min.

Input parameters:

- Solar 10.7cm flux (F10.7)
- 3-Hour Kp index

Assimilated Observations:

- FORMOSAT-7/COSMIC-2 RO ionospheric profiles
- Global GNSS TEC value

Output:

- Ionosphere and thermosphere parameters.
- PNG images for 3 spatial ranges and 4 variables.
- Parameters are outputted with NetCDF file format.

Products:

- Thermospheric parameters along satellite orbit

(a) Location (degree) vs UT (03/09 16:00 to 03/10 06:00)

(b) Altitude (km) vs UT

(c) Neutral density (10¹⁶ g/cm³) vs UT

(d) Neutral temperature (K) vs UT

Fig. Time series of FORMOSAT-7/COSMIC-2 (FS7-1) satellite parameters on 10 March 2025. The panels from top to bottom show (a) the satellite's latitude (magenta) and longitude (blue), (b) its altitude, (c) neutral density, and (d) neutral temperature. The deep blue lines represent 2.5° x 2.5° x 0.25 plev atmospheric parameters, while the light blue lines indicate 5° x 5° x 0.5 plev data.

The Central Weather Administration in Taiwan is responsible for providing space environment information, forecasts, and services.

At present, there are 55 domestic and international space weather products of 28 categories that can be provided. In addition, daily overview and forecasts are manually released. A special watch is issued according to the condition. When severe space weather occurs, an event report is automatically generated and notified on the website.

Welcome to check out the space weather service website (swoo.cwa.gov.tw) for more information, products, and data. We are looking for possible international collaborations.