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Integrated ionospheric irregularity observations over Taiwan

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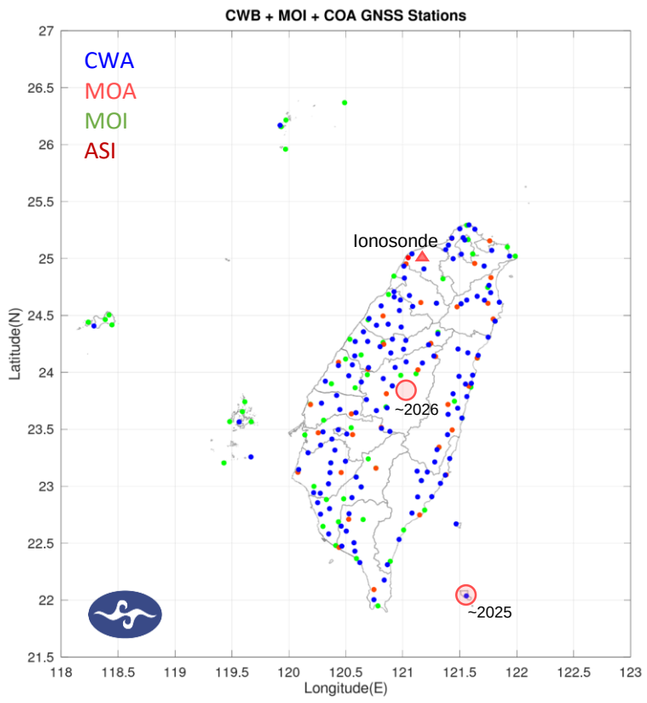
In general, higher plasma density during the day time period overhead is recorded associated with the equatorial ionization anomaly over Taiwan, and to easier observe plasma bubbles/irregularities in the evening to midnight period. Such phenomena would significantly influence high-frequency and satellite communication as well as navigation and positioning services. In order to provide near real-time information of ionospheric electron density distribution for associated users, the Central Weather Administration conducts an integrated observation network together with the Taiwan Space Agency and domestic scientific research teams. These observational instruments including Ground-based GNSS receivers, self-developed all-sky camera, and radio occultation taken by the FORMOSAT-7/COSMIC-2 to conduct the regional map of total electron content (TEC), scintillation index (S4), and rate of TEC index change (ROTI). Recently, many cases reveal ionospheric irregularities via optical and radio measurements, simultaneously. To cross check those observations also give a good chance to analyze the algorithm of data processing. Therefore, it would provide a good dataset to monitor irregularities and quality of positioning signal as well as to have more detailed studies.

Observations and Products

- Ionosonde
- GNSS Ground Network
  - CWA: 140 stations (Trimble & Septentrio)
  - MOA: 35 stations (Trimble)
  - MOI: 80 stations (Trimble)
- FORMOSAT-7/COSMIC-2
  - Scintillation Index (scn1c2, scnLv2)
  - Geo-location products (scnGeo)
- All-sky Imager
  - 2 stations will be installed at 2025/2026



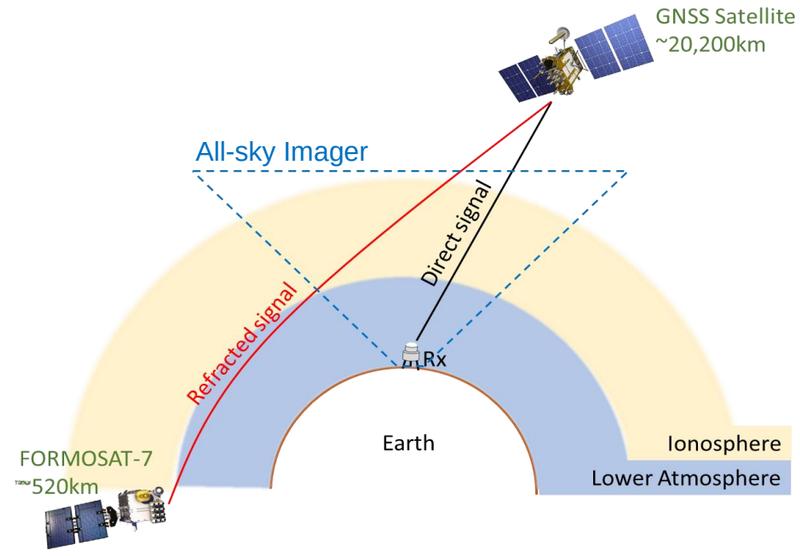


Fig. Integrated ionospheric irregularity observations via satellite (F7/C2) and ground instruments (ionosonde, GNSS receiver, and all-sky imager).

Ionospheric Monitoring via Multiple Ground-based Instruments

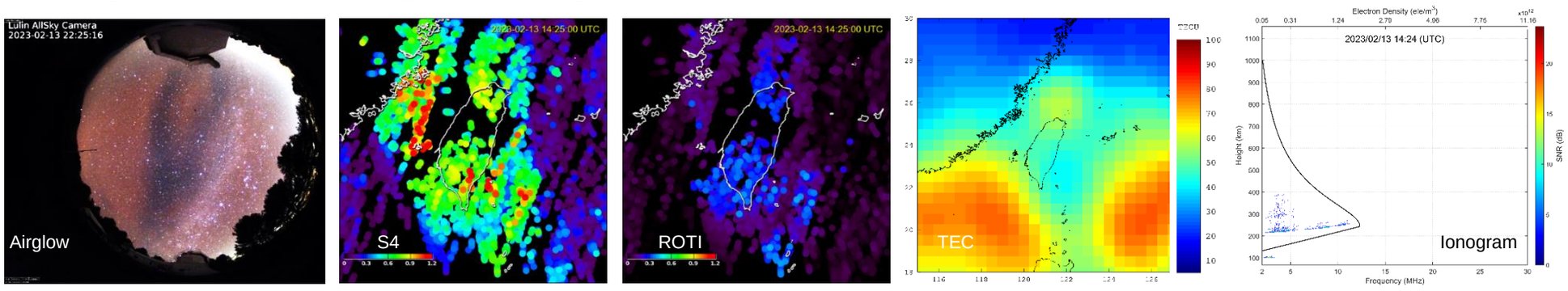


Fig. From left to right are the images of the all-sky camera at NCU Lulin Observatory, GNSS L2-band S4 index, rate of TEC index (ROTI), regional TEC map, and ionogram with true high analysis, respectively, at around 14:25 UT on February 13, 2023. The airglow recorded by the all-sky camera reveals a clear ionospheric plasma bubble, and the ground GNSS network also measures corresponding changes simultaneously. Meanwhile, the ionogram displays Es layer and speared-F at this moment.

Ground and Space Simultaneously Monitoring

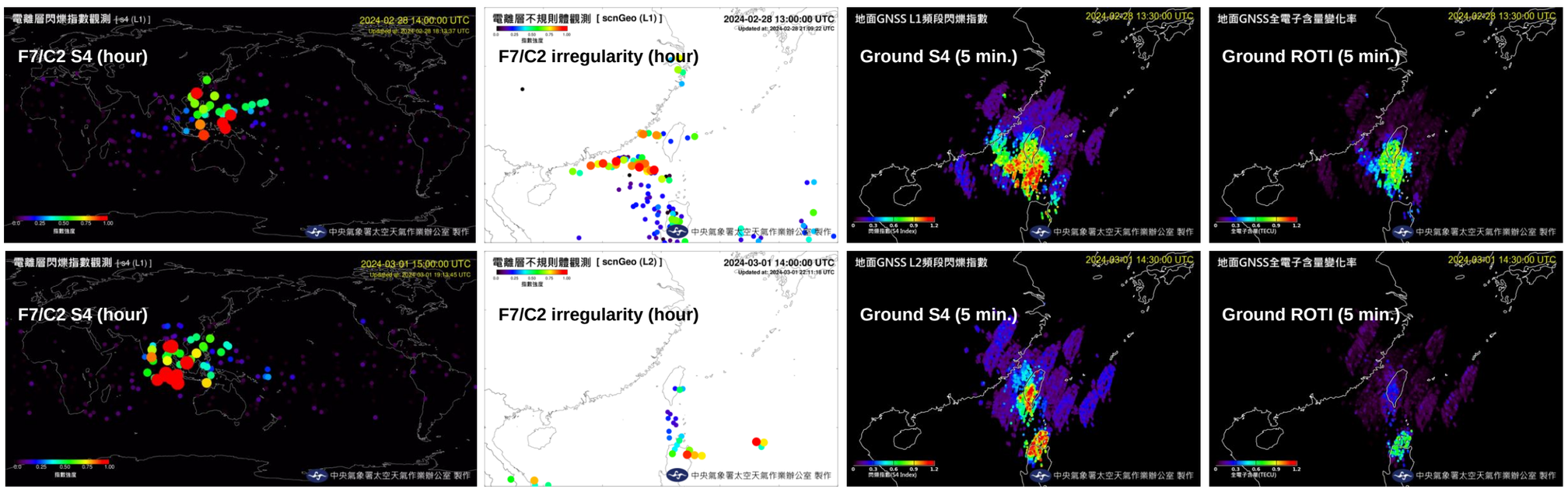


Fig. Left to right are the products of FORMOSAT-7/COSMIC-2, regional GNSS S4 and ROTI map. The S4 map of F7/C2 indicated the maximum value and location of each profile, and the bubble location further estimated from observations to the possible location which caused the signal scintillation. The regional GNSS S4 and ROTI map used the ionospheric point equal to 300 km to project data locations.

- Ionosonde
- GNSS Receivers
- All-sky Imager

- In order to monitor the ionospheric irregularity over Taiwan, the Central Weather Administration integrated various optical and radio instruments to compose a comprehensive system.
- Recently, the FORMOSAT-7/COSMIC-2 provides additional products to indicate the location of ionospheric irregularity, and further reveal a well agreement with ground GNSS observations.
- Space-based observations would combine ground instruments to monitor the ionosphere in real-time.