Indonesia contribution to the regional space weather research and observation

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Introduction

- Indonesia (previously by LAPAN – National Space Agency) joined International Space Environment Services as **Regional Warning Center (RWC)** since 2015, by providing **Space Weather Information and Forecast Services (SWIFtS),** currently organized by Research Center for Space of BRIN,

- This was part of National Space Law on Space (UU RI 21/2013) article 13 on space weather for mitigation, anticipation, national disaster mitigation, and early warning.

New Organization

- Since 2021 LAPAN was integrated into new organization, BRIN, the RWC INDONESIA (SWIFtS) officially changed the domain to $https://swifts.brin.go.id$. The internal business process has also changed.

- While the space activities was organized by INASA (The Indonesia Space Agency Secretariat, /INASA), the operational of SWIFtS are still organized by Research Center for Space, which emphasized on research.

- RWC INDONESIA (SWIFtS) through the Research Center of Space, attended a meeting held by the Director General of Civil Aviation to discuss changes to the Minister of Transportation Regulations regarding Aviation Meteorological Information Services. One of the changes to this regulation accommodates ICAO Annex 3 concerning the Space Weather Service.

Key Issues related to Space
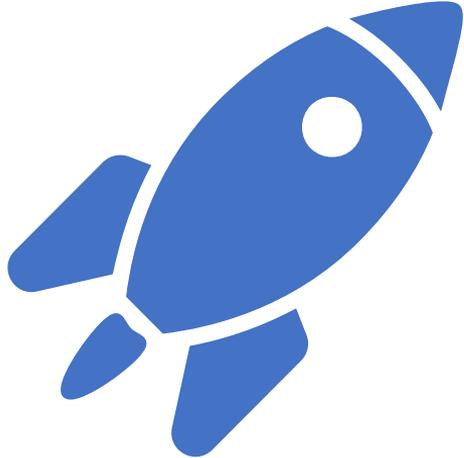
- Indonesia's territory has a wide expanse of longitude, which is almost one eighth of the Earth's equator, a low latitude of geomagnetic coordinates, and a maritime continent, which has so much potential to study the relationship between space and the atmosphere. This is also related to disaster mitigation, in particular from space, which still needs further study.

- Indonesia already has experience in space situational awareness and will continue to advance these subjects:

(1) Space weather, which plays an important role in future space activities. Indonesia is already active in this subject and plays an important role in the SEA region;

(2) Space debris monitoring, which is also an integral part of Indonesian research and activities.

- Global mandates related to space activities, such as ICAO mandate on Annex 3, Ammend 78. Currently Minister regulation on Civil Aviation Safety Regulations Part 174 about Aeronautical Meteorological Information Services (PM 95/2018) is revised to accommodate information regarding Space Weather advisory for national aviation operation.

Key research

- Space weather research: currently we are focusing in solar physics and its activities, dynamics of space environment (solar wind-magnetosphere-ionosphere-upper atmosphere coupling), ionosphere and radio wave propagation studies by using space and ground based observations.

- Research product related to space weather: *Space Weather Information and Forecast Services (SWIFtS),* SWIFtS officially become the 18th member of International Space Environment Service (ISES) as Regional Warning Center (RWC) Indonesia. Currently the web is migrating to the new domain in BRIN: **http://swifts.brin.go.id/** . Development of space weather prediction models for SWIFtS daily operation in **https://swifts.brin.go.id/deluna**

- Space weather application is also related to communication, and navigation which impacted by ionospheric propagation, so Indonesia has strong network of ionospheric observation around the archipelago.

IMPLEMENTATION OF ARTIFICIAL INTELLIGENCE (AI) IN SPACE WEATHER MODELS (https://swifts.brin.go.id/deluna)

- ❑ **25th Solar Cycle Progression and Prediction,** using Machine Learning (ML): Random Forest, Radial Basis Function and Support Vector Machine to predict the time and maximum sunspot number for SC25
- ❑ **Solar Flare Prediction,** using Random Forest (ML), and mixed Multi-Layer Perceptron + Convolutional Neural Network (Deep Learning-DL)
- ❑ **Sunspot and Magnetic Pairs Detection,** using OpenCV
- ❑ **Geoeffective Coronal Holes Detection,** using OpenCV
- ❑ **Solar Wind Speed Forecast,** using Long Short-Term Memory (DL)
- ❑ **Solar Farside Bright Regions Automatic Detection and Prediction of The Sunspot Appearance from The East Solar Limb,** using Random Forest (ML)

IMPLEMENTATION OF ARTIFICIAL INTELLIGENCE (AI) IN SPACE WEATHER MODELS (https://swifts.brin.go.id/deluna)

- ❑ **AI-Generated Solar Farside Magnetogram using STEREO-A (Ahead) Observation,** using conditional Generative Adversarial Network (cGAN) (DL)
- ❑ **Opposite Earth AI-Generated Solar Farside 304 Angstrom and Magnetogram using Solar Farside Seismic Phasemap,** using conditional Generative Adversarial Network (cGAN) (DL)
- ❑ **CME Transit Time and Arrival Speed Prediction (CTArS),** using Random Forest Regression (ML)
- ❑ **24-hr Dst Index Forecast,** using Neural Network (ML)
- ❑ **Solar Summary,** an automatically generated message (called Forecast Report Form–FRF) contains information on solar activity in the last 24 hours and the prediction for the next 24 hours

ASEAN-Oceania JSTIMI/JSEMI Concept Proposal

We propose a *Joint Spatio-temporal Ionosphere Mapping Initiative* (JSTIMI)
Later on, it may become *Joint Space Environment Monitoring Initiative* (JSEMI)

- There are observation data routinely collected by several GNSS CORS networks in the ASEAN-Oceania region.
- Some networks have public access, but some of these networks have a limited distribution policy for the RINEX observation data files (due to export control regulations/laws unique to each national jurisdiction).
- For few selected dates, we may together be able to request RINEX observation data files – separately within our own national boundaries.
- For those selected dates, we will arrange for calibrated TEC, detrended ΔTEC, and ROTI to be computed by the scientific team(s) within each country.
- Afterwards, we can combine the calibrated TEC, detrended ΔTEC, and ROTI from these separate networks into integrated spatio-temporal data maps.

ASEAN-Oceania JSTIMI/JSEMI: Tonga Event Example
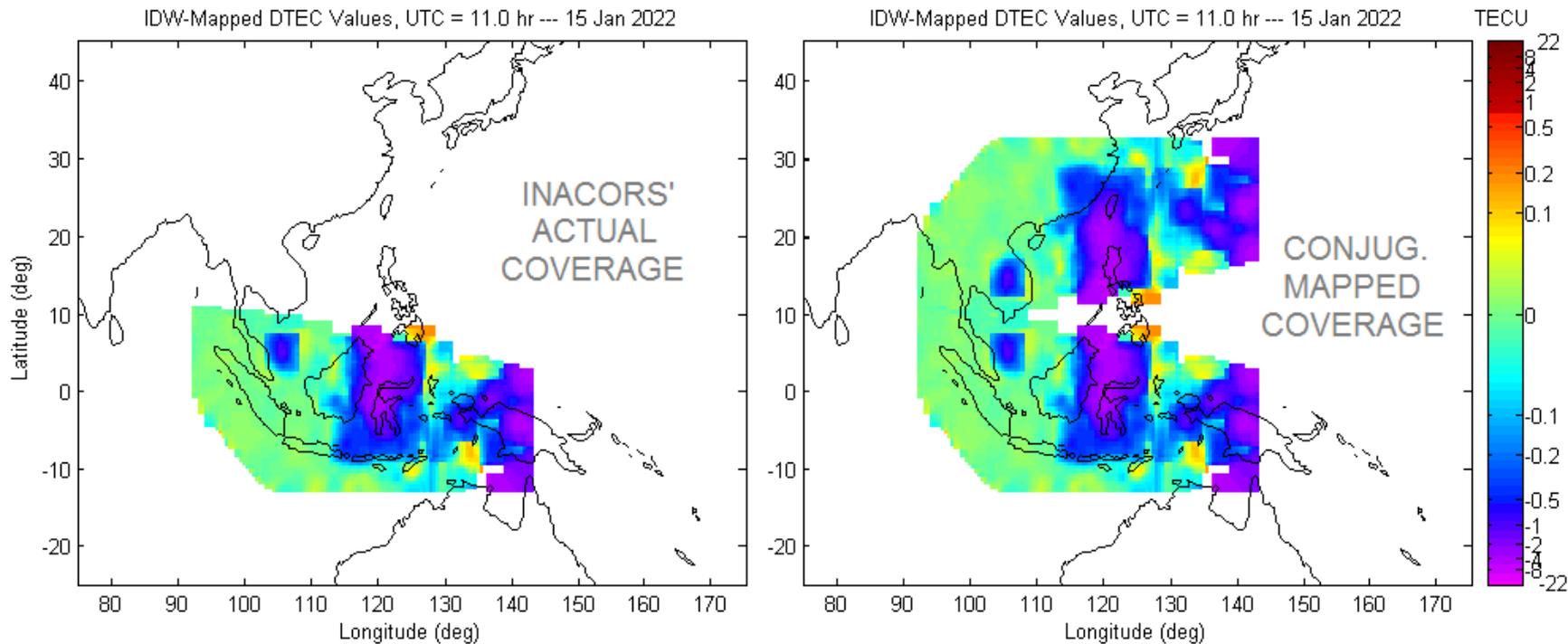


In this example, we have spatio-temporal data map of detrended ∆TEC (from the INACORS network) showing "super EPB" after the 2022 Tonga volcano eruption
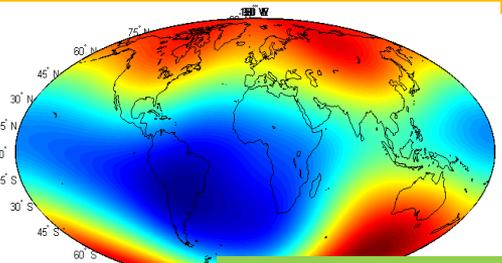
ASEAN-Oceania JSTIMI/JSEMI: Estimated Joint Coverage
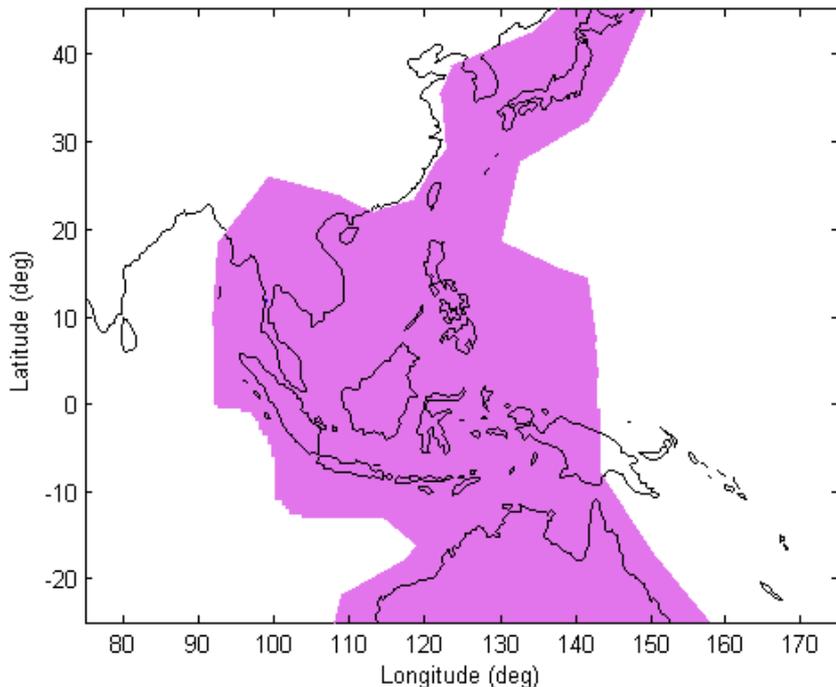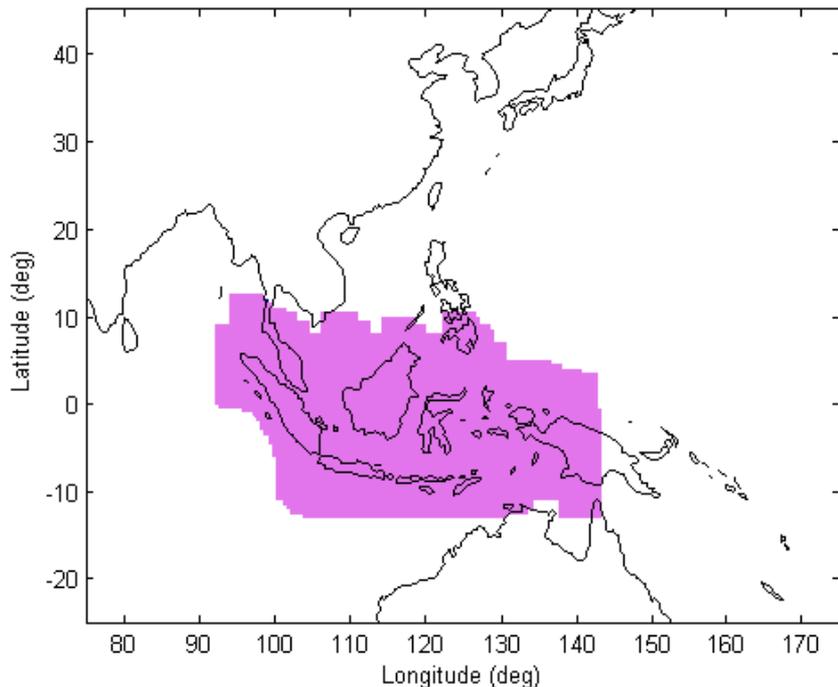
With joint observations from several GNSS network, the total regional coverage of calibrated TEC, detrended ∆TEC, and ROTI data values could be significantly expanded in the true sense (no need for a desperate magnetic conjugate mapping anymore – in the case of ∆TEC data)

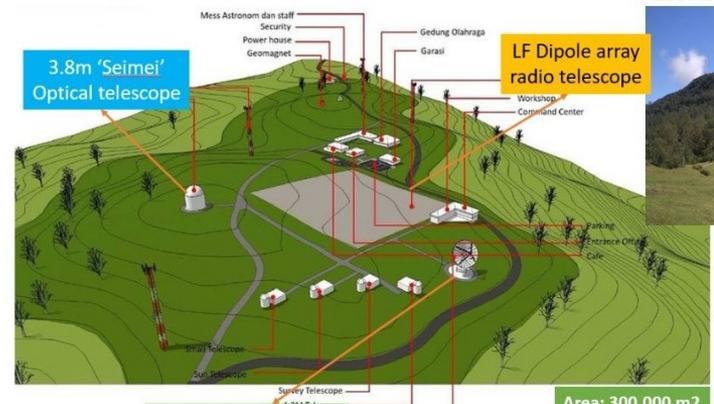# FUTURE SPACE SCIENCE RESEARCH : ASTROPHYSIC & SPACE ENVIRONMENT
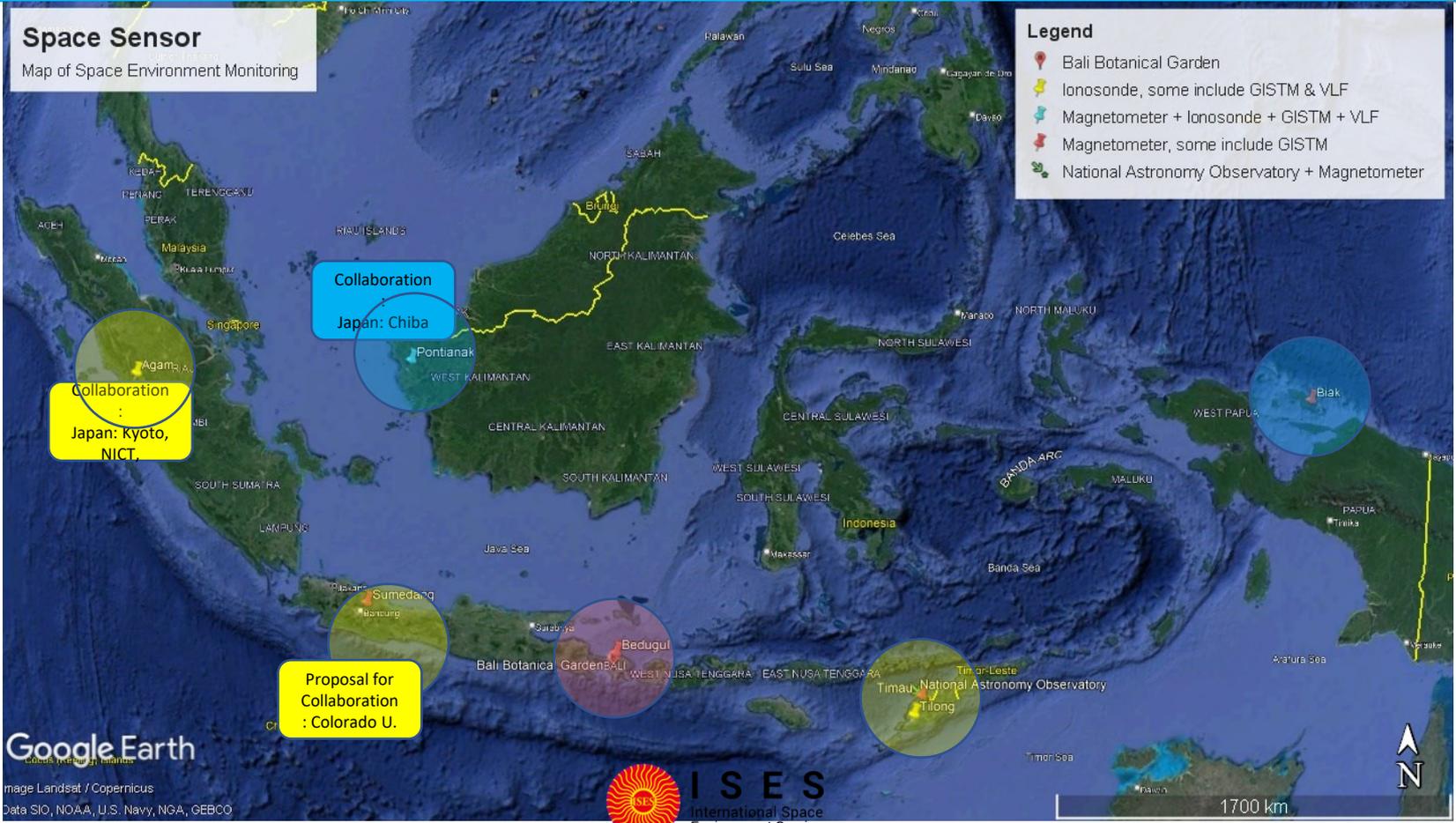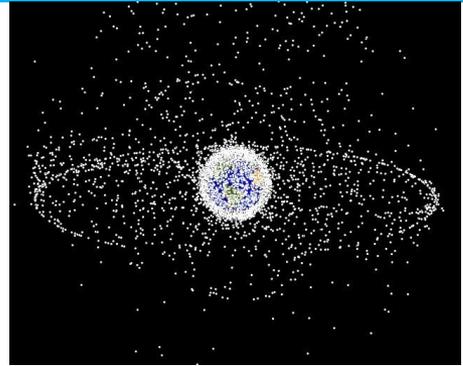
Related research :
- GNSS
- Space situational awareness

Current research :
- Space weather
- Upper atmospheric – space interaction

LAPAN-A3 magnetometer result

ISES International Space Environment Service

Mount Timau, Kupang, East Nusa Tenggara Indonesia

3.8m 'Seimei' Optical telescope

LF Dipole array radio telescope

Mess Astronom dan staff
Security
Power house
Geomagnet
Gedung Olahraga
Garasi
Workshop
Command Center
Parking
Entrance Office
Cafe

Small Telescope
Sun Telescope
Survey Telescope

20m class Parabolic radio telescope

Area: 300.000 m2

Longitude 123°56'24.4" E,
Latitude 9°35'4.9" S, and
Altitude 1352 m. msl

Collaboration

- Collaboration NICT Japan, with the establishment of FMCW Ionosonde in Agam Station, Sumatera, part of SEALION program, still continued,

- AVON (Asia VLF Observation Network) in Pontianak Station, with Chiba University is renewed in 2024,

- Indonesia is also active in SCOSTEP, ISWI, ISWI School and ISELION were also organized in Indonesia in previous year,

- In 2023 several young researchers also join ICTP – SCOSTEP – ISWI School – PRESTO,

- In 2024 we welcome collaboration from ISWI with LoI from Colorado University for deployment instrumentation in Indonesia,

- In 2023 – 2024 collaboration between BRIN & MYSA Malaysia is started and continued,

- Other new collaborations are welcome,

Concluding Remarks

- Indonesia is currently transforming its R2O, with strengthening the research activities & facilities,

- Several stations are re-installed and renew, open for global collaboration,

- Data & facility sharing are welcome, as well as researcher exchanges,

- Several funding scheme are also prepared for future collaboration in Indonesia.

Thank You!

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