

SWCG key recommendations to CGMS plenary

Presented to CGMS-52 Plenary, agenda item 5

Executive summary

- Significant progress has been made in coordination of operational space weather data provision and improving data access and quality to an increasingly mature user community.
- CGMS members continue to operate and plan new space weather missions to meet the user needs.
- Operational thermospheric density measurements crucial to effective space traffic coordination are proposed to be included in the CGMS Baseline /HLPP for the first time.
- CGMS satellite anomalies compiled since 2015 proposed to be published on the CGMS website to provide better insight into the resilience of satellite missions against space weather effects. However, only a few CGMS members are currently providing data and the objectives of the database cannot be achieved without more data from CGMS members and other operators.
- Improving data access outreach events in Asia, Europe and USA are an important activity of the SWCG Task Group and are now being extended to encompass both space-based and ground-based observations covering operations and research users as compatibility in the approach to coordination needs to be maintained.

SWCG and its role within CGMS

The CGMS Space Weather Coordination Group (SWCG) was established by the 46th CGMS plenary on 8 June 2018, building upon the work performed by the former Space Weather Task Team, created in 2015 during CGMS-43.

SWCG co-chairs: Elsayed Taalat, NOAA / Tsutomu Nagatsuma, NICT/JMA

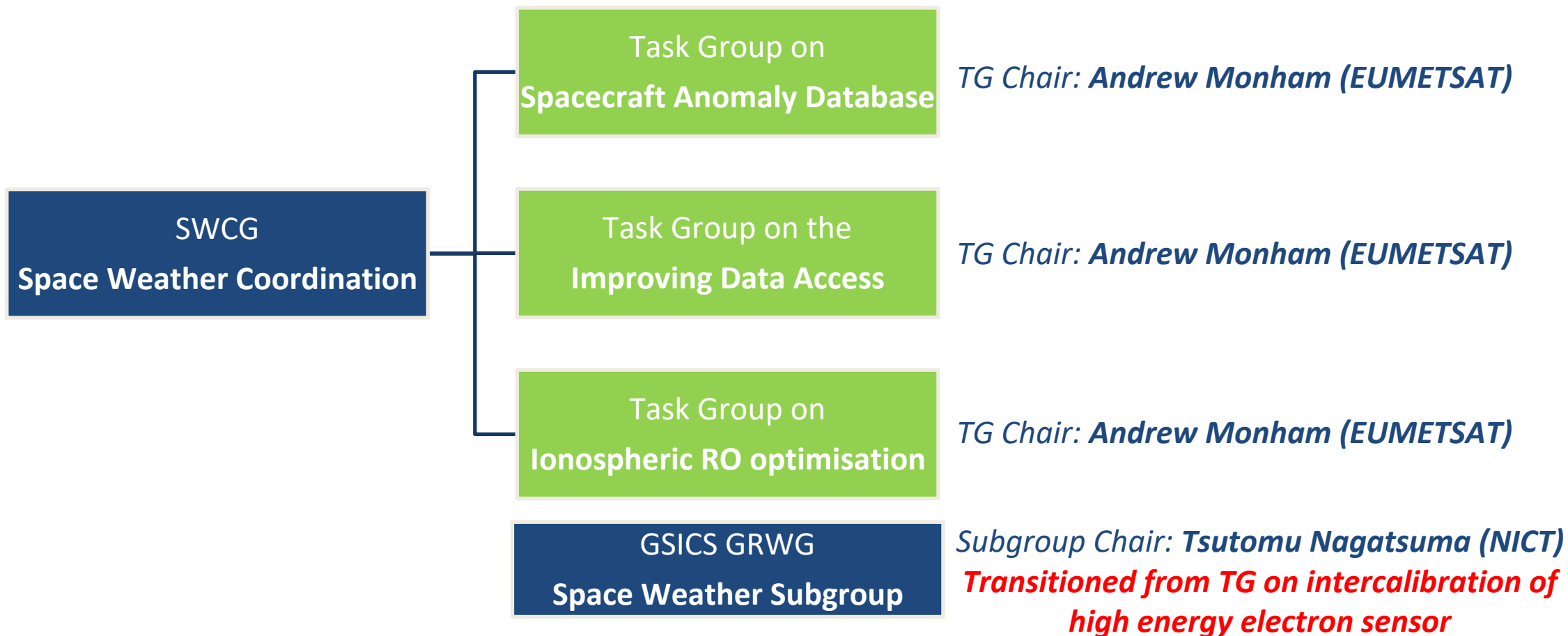
SWCG rapporteur: Andrew Monham, EUMETSAT

SWCG co-rapporteur (pending): Jesse Andries, WMO

Terms of Reference: Objectives (not updated since CGMS-51)

- Coordinate space weather activities within and across CGMS working groups including space weather data, ensuring space weather operational measurements are incorporated into the CGMS baseline, relevant frequencies, anomaly resolution, products, knowledge, policy, etc.;
- Address space weather topics relevant to CGMS that are not currently within the purview of other CGMS WGs;
- Facilitate dialogue between CGMS members and space weather communities;
- Identify which space weather organizations/forums the SWCG should interact with both as an active participant and/or engaging them within CGMS activities;
- Identify needs and requirements from space weather communities that should be managed and coordinated by CGMS or its members;
- Follow current and future international and domestic space weather policies which may have an effect on CGMS or its members; and
- Review the CGMS high level priorities related to space weather.

Current SWCG Structure



TG with *green background* report to the Joint WGI-SWCG-WGIV plenary session



Overview of CGMS-52 SWCG and Joint WGI-WGIV-SWCG Sessions

SWCG Session: 25 WPs (9% more contributions to main agenda items compared to CGMS-51)

SWCG/2: CGMS risk assessment and baseline update -1WPs

SWCG/3: Updates on space-based observational capabilities -5WPs - CMA, ESA, KMA, **NICT**, NOAA

SWCG/4: Updates on space weather activities -8WPs - ESA, EUMETSAT, ISRO, JAXA, NICT, NOAA, WMO

SWCG/5: International space weather data user activities -4WPs - ESA, ISES, **ISRO**

SWCG/6: OSCAR review for space weather -1WP

SWCG/7: **Briefing from GSICS GRWG Space Weather Subgroup** -1WP

SWCG/8: Review of SWCG list of actions -2WPs

SWCG/9: CGMS future direction 2022+ project -1WP

SWCG/10: Review and updating of the HLPP -2WPs

Joint WGI-WGIV-SWCG session: 9WPs

WGI-WGIV-SWCG/2: Establishing a space weather spacecraft anomaly report database -3WPs

WGI-WGIV-SWCG/3: Space Weather data access -3WPs

WGI-WGIV-SWCG/4: Ionospheric Radio Occultation system optimisation -2WPs

WGI-WGIV-SWCG/5: Frequency-related topics in support to space weather -1WP

WGI-WGIV-SWCG/6: Space environment sustainability Space Weather aspects -2WPs

SWCG Main outcomes and future work (1)

- **CGMS risk assessment and baseline update**

- Short-term risks continue regarding measurements at L1 due to reliance on ageing spacecraft DSCOVR, ACE, and SOHO until the NOAA SWFO mission becomes operational. The ISRO Aditya L1 mission won't support real-time data flows. In case of SOHO/LASCO loss, NOAA can provide STEREO-A Coronagraphy. For additional resilience, NOAA NESDIS is planning a low data latency coronagraph data pipeline for timely data delivery from NASA PUNCH mission (2025) as QuickPUNCH.
- Continuity risk exists from ionospheric RO observations due to no commitment for a follow-on to COSMIC-2. A dedicated Risk Assessment for ionospheric RO may be planned in 2025.
- Longer-term risks are associated with the end of programs, including L1 measurements (end of SWFO-L1) and low and high-energy particle measurements in the GEO 86.5°-123°E range (end of FY-4B). Follow-on missions are proposed in respective agencies awaiting approval.
- Vigil at L5 is included in assessments but is deemed complementary to L1 and doesn't mitigate long-term risks associated with L1 measurements.

SWCG Main outcomes and future work (2)

- **Updates on space-based observational capabilities**

- Highlights from Agency presentations include:

- CMA performing thermospheric density and auroral measurements in LEO – it is proposed to consider adding the capabilities and expansion of the need for these measurements in the CGMS baseline and HLPP
- ESA work on Vigil L5 continues and further missions to measure the Aurora and a nano-satellites are in progress.
- KMA are designing a new space weather payload, KSEM-II, for the upcoming GK2A Follow On satellite.
- NICT are developing new Radiation Monitors for Space weather (RMS) for Himawari-10.
- NOAA launch of GOES-U carrying SWFO CCOR on Falcon Heavy scheduled for June 25, 2024. SWFO-L1 Observatory continues development for a 2025 launch and procurement approval of the continued L1 observations under the SW Next program is foreseen in 2024.

SWCG Main outcomes and future work (3)

- **Updates on space weather activities – Agency reports**
 - EUMETSAT space weather roadmap planned to enhance operational space weather data services globally, including: NOAA SEM-2 processor progressing, operational delivery of Metop-GRAS lower ionospheric profile data started, increased redistribution of space weather data via EUMETCast.
 - ESA updates made to products and service pages for the space weather service network
 - ISRO Aditya L1 preliminary observations made from the various instruments. Although data is not delivered in real-time, comparisons with data outputs from existing and planned operational L1 missions will be valuable.
 - JAXA introduced SEES, a database system for space environment data and models. Although not all data are public yet and continuation is uncertain, consideration should be given to incorporating SEES data into baseline observations and rideshare opportunities could help increase observations.
 - NICT are developing new systems to predict large solar flares and updating forecasting and warning criteria., NICT also conducts real-time simulations using GAIA for predicting thermospheric mass density, with ongoing development to assimilate FORMOSAT7/COSMIC2 RO observations into the system for improved accuracy.
 - WMO is has included space weather in the Strategic Plan 2024-2027 and established a 4-year plan for activities across the infrastructure pillars: WIGOS, WIS and WIPPS. WMO's is supporting the build-up of global SWx service capabilities.
 - NOAA/SWPC highlighted existing and planned space weather service observational capabilities, efforts to establish a communication plan for significant SWx events, support for the Artemis lunar mission, and assistance to commercial SWx observational activities.

SWCG Main outcomes and future work (4)

- **International space weather data user activities**
 - ISRO reported on the use of the Indian space weather ground network in ionospheric monitoring through Total Electron Content. Also, innovative measurement techniques for solar wind using signals from satellites orbiting Mars and Venus as they pass through the Sun's inner coronal regions.
 - The International Space Environment Service (ISES) is the primary organization engaged in the coordination of space weather services and in the framework of WMO-ISES-COSPAR Coordination Team. ISES are discussing future plans and requirements with CGMS/SWCG in SWW, ESWW and AOSWA as well as the SWCG task groups as a data user community.
 - Space Traffic coordination needs for space weather inputs were discussed, linking to the Space Situational Awareness theme as part of the CGMS future direction 2022+ and the newly formed WGI Task Group on Space Environment Sustainability which incorporates the SSA objectives including the need for improved space weather service interactions with spacecraft operators. Close coordination between this WGI TG and SWCG is foreseen.
 - WMO reported on the first International Space Weather Coordination Forum meeting in November 2023, an initiative backed by UNCOUOS. For global space-based coordination, an International Agency Space Weather Coordination Group (IASWCG) for both operational and research missions was proposed. An open discussion was held on international efforts related to the needs of Space Traffic Coordination services, with thermospheric measurements being identified as critical.

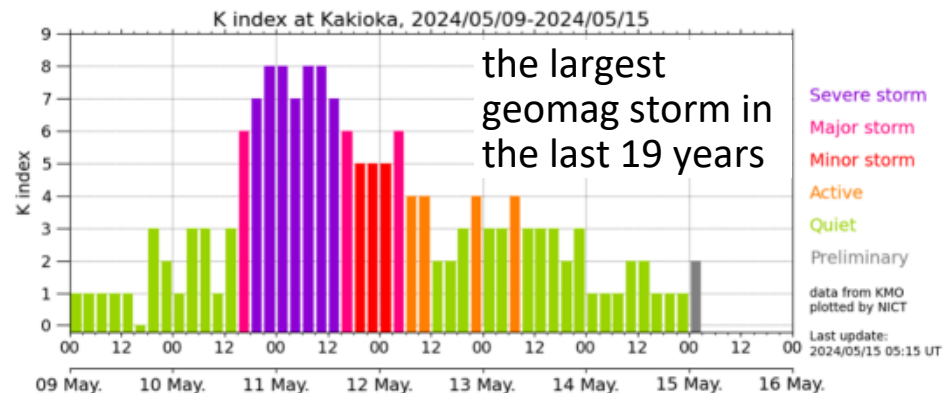
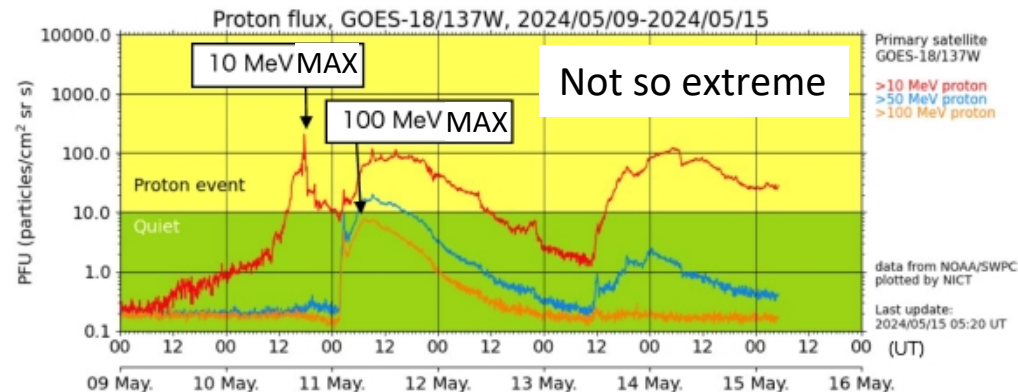
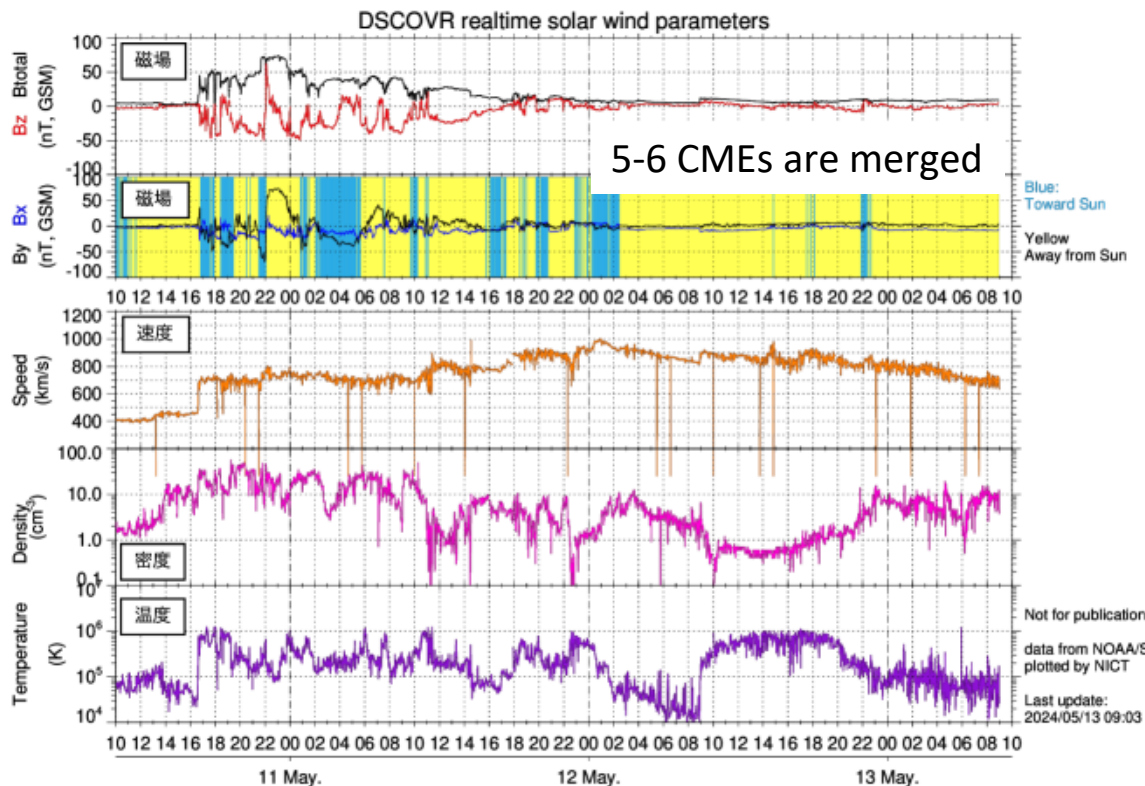
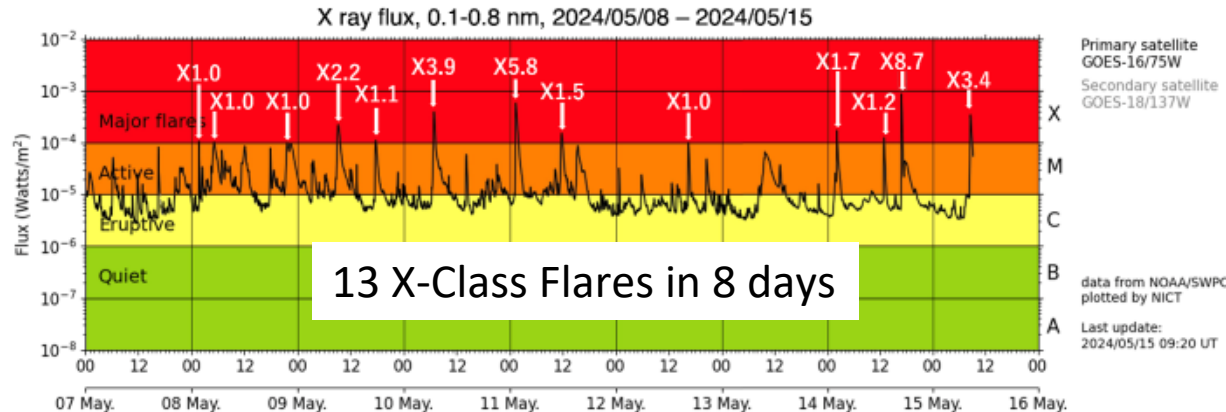
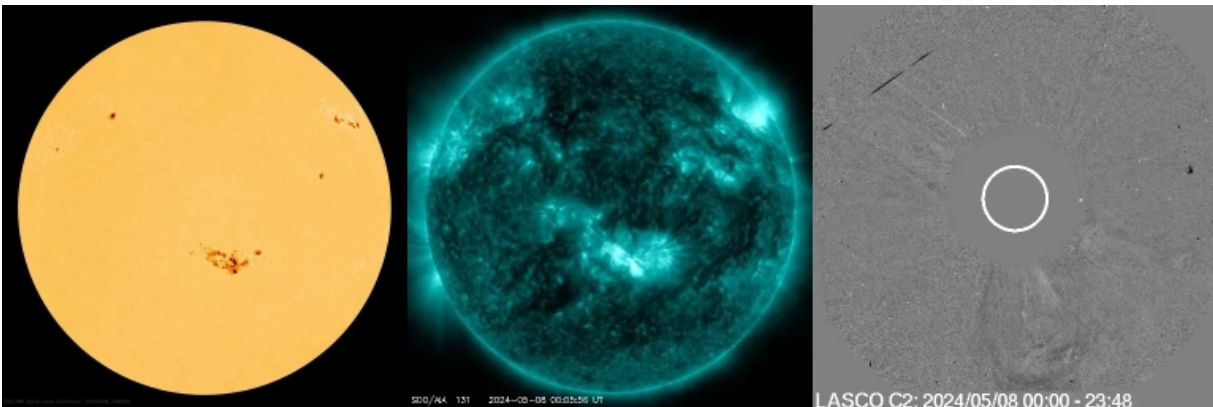
SWCG Main outcomes and future work (5)

- **OSCAR review for space weather - Completeness and suitability of space weather related content**
 - WMO reported on the gap analysis for space-based observation capabilities comparing capabilities recorded in OSCAR/Space to the WMO WIGOS Vision requirements for the period 2024-2034. For space weather, gaps are identified for the interplanetary solar wind and in-situ magnetic field at L1, solar coronagraph at L1 after 2033 and radio-waves in the ionosphere.
- **Briefing from GSICS GRWG Space Weather Subgroup on Intercalibration**
 - The activities of the GSICS GRWG Space Weather Sub-group began in 2023 as a result of the SWCG task group focused on inter-calibration of high energy electron sensors. The sub-group's scope and work plan were established, and during the breakout session at the 2024 GSICS Annual Meeting, member organizations reported on cross-calibration activities. To standardize the cross-calibration procedure for high energy particle sensors, the COSPAR/PRBEM standard data procedure document was reviewed. It was recognized that several issues need to be discussed with COSPAR/PRBEM members to apply this document to GEO high energy particle cross-calibration. A meeting for this discussion is planned for COSPAR 2024. It is recommended that CGMS/SWCG continue collaborating with the GSICS GRWG Space Weather Sub-group to share information and engage in discussions.

Joint WGI-WGIV-SWCG Main outcomes and future work (1)

- **Space Weather Spacecraft Anomaly Database Task Group:**
 - TG activity has strong support from UN COPUOUS with the Long Term Sustainability (LTS) Guidelines. CGMS/WMO have drafted a compliance matrix.
 - However, only a few CGMS members are currently supplying anomaly data and this must be expanded to other members and operators beyond CGMS to achieve the objectives of the database.
 - It is proposed to publish all anomaly data received since 2015 in the latest Excel template format on the CGMS website after approval at CGMS-52 Plenary meeting.
 - Work under an on-going NASA/NOAA contract may help create a database structure for anomalies while addressing security and confidentiality concerns. A dedicated presentation was made on the progress by the contractor.
 - Effort on compiling EDAC scrubbing data started in EUMETSAT and SWCG invite SWx analysts to report the value of these data. If confirmed useful, a request for further CGMS member inputs, including historical data will be made and published in the anomaly database.
 - Interactions with satellite operators and space weather service representatives have taken place at the ESWW and are planned at AOSWA.
 - In the lead up to CGMS-53, TG plans to work on expanding extent of anomaly data feedback.

Overview of Extreme Space Weather event on May 08-12, 2024



Survey results from CGMS members

- 1. Please let us know if severe space weather disturbances over the past few days have had an impact on your satellite operations or the satellite itself.**
 - Most of the GEO and LEO satellites did not report having anomalies and/or no more anomalies than usual.
 - Some of LEO satellites experienced significant increase in attitude control momentum wheel speeds. At least one mission experienced safe-mode for this reason. The increase in attitude control momentum could have become critical if the satellite altitude were lowering the orbit for end-of-life re-entry.
 - Some of LEO satellites experienced error of the orbit determination algorithms.
- 2. Please let us know if you have implemented any measures for the satellite or satellite operations due to severe space weather disturbances over the past few days.**
 - No special operational measures were required during the storm period (apart from the manual interventions mentioned above)
 - No reports of significant preparations taken.
 - The satellite operations implemented heightened monitoring awareness and internal reporting measures when SWx Forecasting Center issues alerts of severe space weather disturbances.

The following CGMS members gave feedback to TG : CMA, EUMETSAT, ISRO, JMA, JAXA, NASA, NOAA

Joint WGI-WGIV-SWCG Main outcomes and future work (2)

- **Task Group on Improving User Data Access to Space Weather Data from Orbital Sensors**
 - The Task Group has been leading CGMS outreach events to in space weather workshops in Asia, Europe and the USA.
 - These outreach events are now being extended to encompass both space-based and ground-based observations covering operations and research users as compatibility in the approach to coordination needs to be maintained.
 - Work is commencing on the future approach for compatible formats and metadata for both Ops and research needs.. A new action to identify and remove inconsistencies on space weather product level definitions was raised.
 - Improvements in data access are being implemented in EUMETSAT through EUMETCast redistribution and EUMETSAT/ESA/WMO have cooperated on making SOSMAG data available (non-operational latency) as a trial.
 - SWCG and WMO-ET SWx coordinate on the role of WIS2.0 in supporting operational space weather dissemination.
- **Ionospheric Radio Occultation system optimisation**
 - The TG has progressed in compiling the table of ionospheric RO mission capabilities, reviewing methods for geolocating plasma bubble scintillation and initiating Observing System Simulation Experiments (OSSEs).
 - NOAA aims to understand needs for ionospheric RO observations for commercial data purchases and a potential government RO backbone. A preliminary assessment suggests a need for around 30,000 RO profiles per day.
 - Future work includes OSSE studies to determine optimal RO occultation numbers for data assimilation improvements, and architecture studies for TEC, electron density profiles, and scintillation coverage and refresh.
 - On invitation of the current TG leader, NOAA intend to propose a new leader for the TG.

Joint WGI-WGIV-SWCG Main outcomes and future work (3)

- **Frequency-related topics in support to space weather**
 - Before WRC-23, the ITU Radio Regulations (RR) didn't address space weather observations using radio frequencies. At WRC-23, this issue was addressed under agenda item 9.1 Topic A, with a two-step approach:
 - Dealing with space weather frequency issues
 - Studying specific frequency bands for regulatory provisions for receive-only space weather sensors.
 - WRC-23 established Space Weather designation under a new sub-category of MetAids in RR Article 29B, along with ITU-R Resolution 675 emphasizing space weather applications and defining space weather. WRC-27 agenda item 1.17 was created for possible frequency allocations to MetAids in certain bands. Practical effects were discussed regarding existing space radio astronomy allocations, with emphasis placed on areas requiring allocation.
 - WMO acknowledged progress at WRC-23 on space weather items and expressed appreciation for the efforts.

Joint WGI-WGIV-SWCG Main outcomes and future work (4)

- **Space environment sustainability Space Weather aspects**
 - The space weather aspects of the WGI Task Group on Space Environment Sustainability were presented. CGMS members involved in space operations or providing SSA/Space Weather data to spacecraft operators are invited to participate. ISES Membership is also invited to support space weather service utilization by spacecraft operators. It was clarified that the TG's objective regarding space weather is the usage of forecast information rather than forecasting itself.
 - ESA presented their user engagement activities from the start of the development process through to testing of end results. An ESA SWE Portal upgrade was completed in 2023 to include a section dedicated to guidance for end users, manuals, tutorials etc. The Customer Requirements were updated in 2023 and all user domains were reviewed.

Key recommendations to CGMS plenary

- Plenary invited to note that operational thermospheric density measurements, crucial to effective space traffic coordination, as well as auroral observations, are to be considered by SWCG for inclusion in the CGMS Baseline /HLPP for recommendation to CGMS-53.
- Ionospheric RO is recommended to undergo a dedicated risk assessment in 2025 as the distinct needs become better defined.
- CGMS satellite anomalies compiled since 2015 proposed to be published on the CGMS website. However, only a few CGMS members are currently providing data and the objectives of the database cannot be achieved without more data from CGMS members and other operators.
- SWCG Terms of Reference will be reviewed and updated, based on the CGMS Future Directions Project outcomes and inputs from the Task Groups for presentation to CGMS-53
- Due to the increasing importance to CGMS members of operational space weather observational systems, the maturing of capabilities and future expansion plans, it is recommended to plan for a dedicated space weather coordination agenda point as part of the CGMS-53 plenary.
- Jesse Andries of WMO is proposed as a SWCG co-rapporteur to support Andrew Monham (EUMETSAT)