International Civil Aviation Organization

INFORMATION PAPER (IP/04)

ICAO ASIA AND PACIFIC (APAC)
THIRTIETH MEETING OF THE METEOROLOGY SUB-GROUP (MET SG/30)

Bangkok, Thailand, 20 - 24 July 2026

Agenda Item 5: Planning and Monitoring

CONSOLIDATED SPACE WEATHER INFORMATION SERVICE MANAGEMENT REPORT FOR 2025

(Presented by Australia)

SUMMARY

This information paper presents the first consolidated management report for the Space Weather Information Service which was approved by the Meteorology Panel (METP) Working Group on Meteorological Operations Groups (WG-MOG) for Space Weather (SWX) Work Stream. The reporting period is from 1 January to 31 December 2025.

1. INTRODUCTION

1.1 The ICAO Space Weather (SWX) Information Service (SWIS) became operational on 7 November 2019. The operation of the SWIS is overseen by the METP WG-MOG SWX Work Stream and managed by the Space Weather Centre (SWXC) Coordination Group (SWXCCG) which is comprised on four global and one regional SWXC designated by ICAO.

1.2 The WG-MOG SWX Work Stream has formally request that the SWXCCG develop an annual management report for the SWIS to support the oversight responsibilities of the METP. Therefore, similar to the WG-MOG International Airways Volcano Watch (IAVW), the WG-MOG-SWX will produce an annual report for each calendar year. This report is for 1 January to 31 December 2025.

2. DISCUSSION

2.1 The content of the consolidated management report for SWIS closely resembles the consolidated management report for the International Airways Volcano Watch (IAVW). The outline of the consolidated management report for the SWIS is shown in the table below.

Content of Consolidated Management Report for the Space Weather Information Service	
Executive Summary	2.5 Operational Continuity of the Service
Acronyms List	3.0 Future Developments and Service Improvements
Reference document list	4.0 SWXC Activities in 2025
1.0 Introduction	ACFJ Report
2.0 Discussion on operations	CRC Report
2.1 Space Weather Conditions in 2025	PECASUS Report
2.2 Overview of Advisories Issued Per SWXC Per Effort During the Reporting Period	SWPC Report

2.3 Finding on the Useability of Advisories	SANSA Report
2.4 Results of Key Performance Indictors	Appendix A Requirements for SWXCs

2.2 The report provides an overview of the solar activity for 2025 showing the x-ray flux, the solar proton flux and geomagnetic activity compared to when the space weather advisories were issued by each SWXC. The yellow and red areas represent the moderate (MOD) and severe (SEV) thresholds for the space weather advisories (Figure 1).

Figure 1. An overlay of when the advisories were issued by each of the SWXCs compared to solar and geomagnetic activity in 2025. The top panel indicates which centres were on duty when RAD, HF COM, and GNSS advisories were issued. Shaded squares and lines show the individual space weather events with yellow representing MOD and red representing SEV. The second and third panels show the X-ray flare activity and relativistic proton flux which are measured near the Earth by the GOES satellite. The bottom panel shows geomagnetic activity indicator Kp (source GFZ Potsdam).

2.3 The Table 1 shows the number of space weather advisories (SWXA) issued per SWXC for High Frequency Communication (HF COM), Global Navigation Satellite System (GNSS) and Radiation (RAD). In total, there were 738 SWXA and 23 test SWXA issued. The SWXCCG and the METP WG-MOG SWX are continually looking at harmonisation between the SWXCs to ensure guidance is used in the same way. Some difference can be attributed to when the solar activity occurs and which SWXC in the on-duty centre.

	GNSS	HF COM	RAD
ACFJ	223 (1)	95 (1)	0
CRC	0 (1)	24 (1)	0 (6)
PECASUS	211 (2)	169	0 (2)
SWPC	10 (2)	7 (7)	0

Table 1. Number of advisories issued by the SWXCs in 2025 for the different effects and for testing purposes (in round brackets).

2.4 The Key Performance Indicators for SWX are:

- 90% of the SWXAs must be issued within 15 minutes after the time when the threshold for advisory issuance is met, and
- 99% of the SWXAs are issued with no syntax errors, no numbering errors and permit automated processing by end-users.

2.5 For the 2025 reporting period, generally 90% of the issued and checked SWXA showed a latency of less than 15 minutes. There were 8 advisories which were non-compliant so the 99 % KPI was also achieved.

2.6 Further detail on the above information and other topics can be found within the full Consolidated SWIS management report in Appendix A.

3. ACTION BY THE MEETING

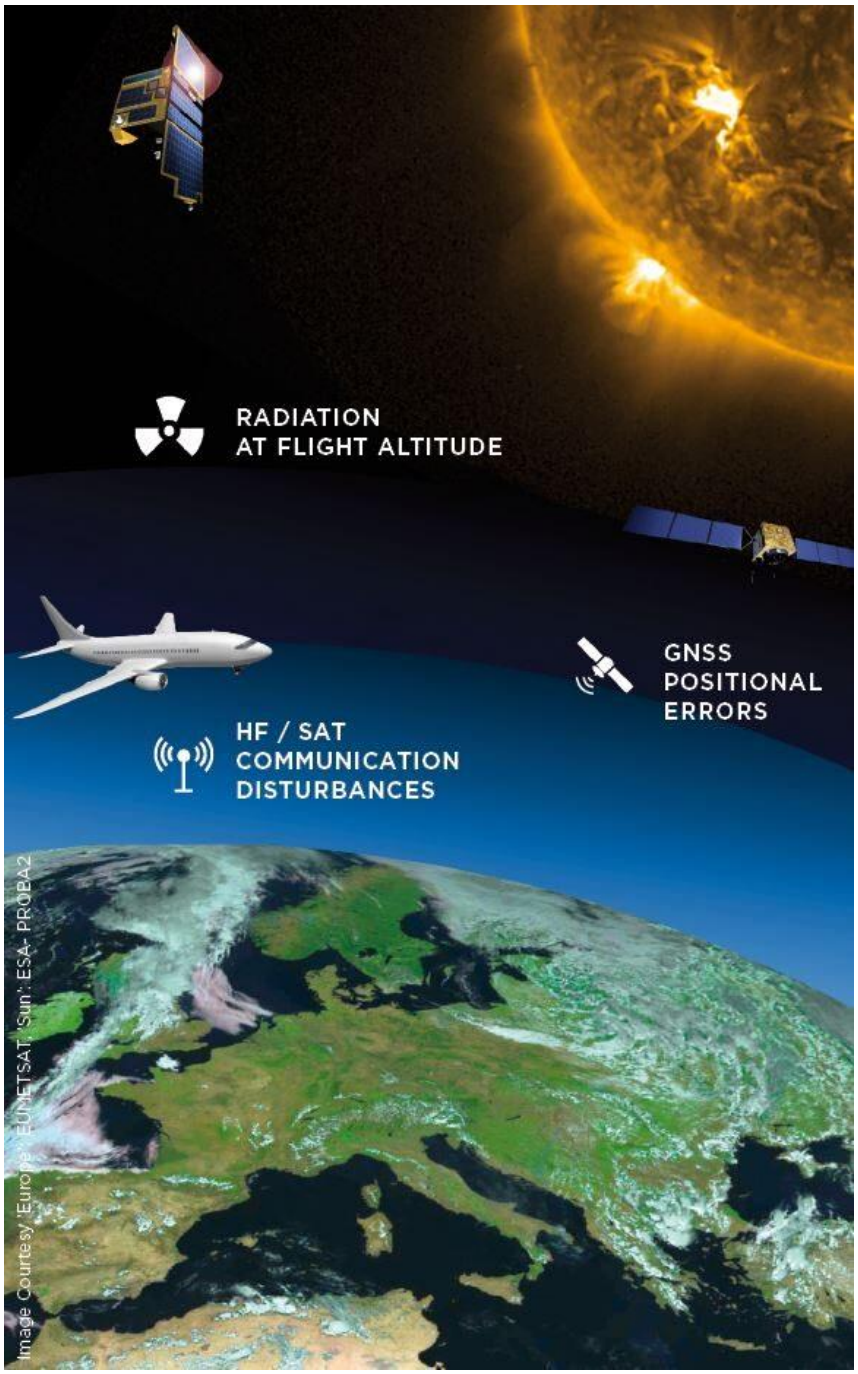
3.1 The meeting is invited to:

a) note the information contained in this paper and Appendix A.

– – – – – – – – – – – – – – –

APPENDIX A

Consolidated Space Weather Information Service Management Report for 2025



Version	Date	Change record	Approved
0.1	18 May 2026	Draft	
1.0	11 June 2026	Final	METP WG-MOG/35-SWX

EXECUTIVE SUMMARY

The International Civil Aviation Organization (ICAO) Space Weather (SWX) Information Service (SWIS) became operational on 7 November 2019. The operation of the SWIS is managed by the SWX Centre (SWXC) Coordination Group (SWXCCG) which is comprised of four global SWXCs and one regional SWXC designated by ICAO to provide the service. The ICAO Meteorology (MET) Panel (METP) is responsible for overseeing the operation of the SWIS. This responsibility is delegated to the SWX Work Stream under the METP Working Group on MET Operations Groups (WG-MOG).

To facilitate the execution of its oversight responsibilities, the WG-MOG SWX Work Stream requested that the SWXCCG produce an annual report on the operation of the SWIS for each calendar year (1 January to 31 December). The first annual report produced by the SWXCCG was for the year 2024. The annual report on the operation of the SWIS is based on the consolidated management reports produced by the ICAO-designated providers of the International Airways Volcano Watch (IAVW) and the World Area Forecast System (WAFS).

The consolidate SWIS management report includes input from the four global SWXCs and the one regional SWXC about the operation of the SWIS, further development and improvements of the SWIS, and select activities of each SWXC relevant to the SWIS. The content of the report is intended to assist the SWXCs in identifying and mitigating any issues with the provision of the SWIS, as well as communicating the performance of the SWIS to the various user communities and stakeholders that utilize space weather information for international civil air navigation.

The consolidated SWIS management report is expected to change over time as the service changes in response to the needs and requirements of aviation decision-makers, as well as technological and operational improvements implemented by the designated SWXCs. Thus, the content and format of the consolidated SWIS management report may differ from year to year based on feedback from the SWXCCG.

Table of Contents

ACRONYM LIST

Acronym	Term
ACFJ	Consortium comprised of Australia, Canada, France and Japan
ACE	Advanced Composition Explorer
AMC	Civil Aviation Meteorological Center
AMD	Amendment (to ICAO Annex 3 and PANS-MET)
ANC	Air Navigation Commission
ATMB	Air Traffic Management Bureau
CAAC	Civil Aviation Administration of China
CAA NZ	Civil Aviation Authority of New Zealand
CMA	China Meteorological Administration
CLS	Collecte Localisation Satellite
CRC	Consortium comprised of People's Republic of China and Russian Federation
DEP	Post Storm Depression
DSCOVR	Deep Space Climate Observatory
EACCC	European Aviation Crisis Coordination Cell
ESSP	European Satellite Service Provider
EGNOS	European Geostationary Navigation Overlay Service
ET-SWx	Expert Team on Space Weather
EUROCONTROL	European Organisation for the Safety of Air Navigation. A Pan-European civil-military organization dedicated to supporting European aviation
EUV	Extreme Ultraviolet
FAA	Federal Aviation Administration
FY	FengYun satellite series
FMI	Finnish Meteorological Institute
GFZ	Helmholtz-Zentrum für Geoforschung
GLE	Ground Level Enhancement
GNSS	Global Navigation Satellite System
GOES	Geostationary Operational Environmental Satellite (USA)
GOMS	Geostationary Operational Meteorological Satellite (Russia)
HF	High Frequency
HF COM	High Frequency Communications
IAG	International Association of Geodesy
IAVW	International Airways Volcano Watch
ICAO	International Civil Aviation Organization
INFCOM	Commission for Observation, Infrastructure and Information Systems of the World Meteorological Organization
IRI	International Reference Ionosphere
ISO	International Organization for Standardization
KNMI	Royal Netherlands Meteorological Institute (Koninklijk Nederlands Meteorologisch Instituut)
KPI	Key Performance Indicator
MeV	Mega electron-volt
MOC	Maintenance and Observation Centre
NCSW	National Center for Space Weather
NEMA	National Emergency Management Agency
NICT	National Institute of Information and Communications Technology
NOAA	National Oceanic and Atmospheric Administration
NR RPLC	No Replacement Number
NSMC	National Satellite Meteorological Centre
ODC	On Duty Centre
PAA	Polar cap and Auroral Absorption
PANS-MET	Procedures for Air Navigation Services – Meteorology
PBC	Primary Backup Centre
PECASUS	Partnership of Excellence for Civil Aviation Space weather User Services (Consortium comprised of Finland, United Kingdom, Belgium, Austria, Cyprus, Germany, Italy, Netherlands and Poland)

pfu	Proton Flux Unit
QMS	Quality Management System
RAD	Radiation
RD	Reference Document
RMK	Remarks
ROSHYDROMET	Russian Federal Service for Hydrometeorology and Environmental Monitoring
SANSA	South-African National Space Agency
SARPs	Standards and Recommended Practices
SBAS	Satellite-Based Augmentation System
SBC	Secondary Backup Centre
STCE	Solar-Terrestrial Centre of Excellence
SWIM	System Wide Information Management
SWIS	Space Weather Information Service
SWPC	Space Weather Prediction Centre
SWX	Space Weather
SWXC	Space Weather Centre
SWXCCG	Space Weather Centre Coordination Group
TEC	Total Electron Content
TTX	Table-Top Exercise
UTC	Coordinated Universal Time
UV	Ultraviolet
WAAS	Wide Area Augmentation Service
WAFS	World Area Forecast System
WASAVIES	Warning System for AVIation Exposure to Solar Energetic particleS
WG-MOG	Working Group on Meteorological Operations Groups
WIS	WMO Information System
WMO	World Meteorological Organization
WS	Work Stream

REFERENCE DOCUMENT LIST

RD-1 ICAO Annex 3 20th Edition July 2018, https://store.icao.int/en/annex-3-meteorological-service-for-international-air-navigation-1

RD-2 Doc 10100 Manual on Space Weather Information in Support of International Air Navigation First Edition 2019, https://store.icao.int/en/manual-on-space-weather-information-in-support-of-international-air-navigation-doc-10100

RD-3 Space Weather Information Service Demonstration Process. Audit procedures and reporting templates, 19 January 2018, WMO Secretariat.

1. INTRODUCTION

Space weather (SWX) constitutes a potential risk to aviation. To mitigate these risks, it was recognized that a SWX Information Service (SWIS) would be beneficial to the aviation sector. SWX has been included in the International Civil Aviation Organization (ICAO) Annex 3 since the Twentieth Edition, July 2018. Resulting from ICAO State Letter AN 10/1-IND/17/11 (dated June 9, 2017) with the *Request for interest in providing a space weather information service*, a number of countries and consortiums comprised of several partnered countries, were audited against the ICAO requirements to provide SWX services. These requirements are listed in Appendix A. Based on the successful audits of these SWX Centres (SWXCs) and two ICAO Council decisions, four global SWXCs and one regional SWXC were eventually designated by ICAO. Operations started on 7 November 2019. The one regional SWXC was fully integrated into the operational SWX information service on 27 November 2025.

Four global SWXCs were designated by the ICAO Council at the seventh meeting of its 215th Session on 13 November 2018 (Council decision C-DEC 215/7). These SWXCs are:

- The ACFJ consortium formed by Australia, Canada, France and Japan (http://www.bom.gov.au/aviation/space-weather-advisories/).
- The CRC consortium formed by the People's Republic of China and the Russian Federation joined the operations starting in December 2020 (https://www.spaceweather-service.com).
- The Partnership of Excellence for Civil Aviation Space weather User Services (PECASUS) formed by Finland (lead), Belgium, United Kingdom, Poland, Germany, Netherlands, Italy, Austria, and Cyprus (https://pecasus.eu/).
- The Space Weather Prediction Centre (SWPC) of the National Oceanic and Atmospheric Administration (NOAA) in the United States of America (https://www.swpc.noaa.gov/).

The one regional SWXC integrated into the global SWIS service is operated by the South-African National Space Agency (SANSA) (https://spaceweather.sansa.org.za/).
The four global SWXCs perform SWX monitoring and forecasting in two-week shifts with one SWXC serving as the On Duty Centre (ODC) and the others serving as Primary Backup Centre (PBC), Secondary Backup Centre (SBC) and Maintenance and Observation Centre (MOC). This scheme was chosen to optimize the availability of the combined SWXCs.

A SWX Centre Coordination Group (SWXCCG) is responsible for (off-line) coordinating operational activities and service improvements. Further service improvements are also discussed by the ICAO Meteorology Panel's (METP) Working Group on Meteorological Operations Groups (WG-MOG) SWX Work Stream (WS) and its ad hoc groups. The METP WG-MOG SWX WS is also responsible for the preparation of proposals for Amendments (AMDs) to Annex 3 and the *Procedures for Air Navigation Services — Meteorology* (PANS-MET). Improvements in standards and practices for SWX in general are discussed by the Expert Team on Space Weather (ET-SWx) of the Commission for Observation, Infrastructure and Information Systems (INFCOM) of the World Meteorological Organization (WMO).

This report constitutes the SWIS Management Report for the combined SWXCs over the period 1 January – 31 December 2025[1]. The SWIS is still a relatively new system, it is foreseen that the

[1] This report is comprised of elements taken from the Consolidated Volcanic Ash Advisory Centre Management Report and the World Area Forecast System Management Report.

content of this Management Report and the Key Performance Indicators (KPIs) will evolve over the coming years, thereby moving from performance-based toward more quality-based KPIs.

The outline of this report is as follows. In Section 2, the SWX conditions in 2025 are discussed together with various statistics about the advisories that have been issued by each global SWXC. Additionally, minor errors in the advisories are also discussed and the KPIs are introduced. Special attention is paid to the continuity of the SWIS regarding the ICAO requirements. In Section 3, future developments and service improvements are discussed. A description of selected activities by each SWXC is included in Section 4.

2. DISCUSSION OF OPERATIONS

2.1 Space Weather Conditions in 2025

This section presents the SWX conditions in 2025 during the solar maximum phase of Solar Cycle 25. Activity reported in the SWIS management report shows that the solar activity in 2025 was quite strong. Figure 1 shows the solar activity cycles since 1985 (top) and the activity in 2025 (bottom), as represented by the F10.7 cm radio flux which is sourced from the Penticton solar radio flux. Operations by the four global SWXCs started at solar minimum in 2019 and covered the ascending phase of Solar Cycle 25.

Figure 3 provides a detailed overview of solar activity in 2025 including X-ray flares, high-energy particle events, the interplanetary magnetic field and solar wind, and the geomagnetic K_p index. Solar X-ray flux and solar proton flux are measured near the Earth by the Geostationary Operational Environmental Satellites (GOES). Interplanetary and solar wind parameters were measured by a combination of the Advanced Composition Explorer (ACE) and Deep Space Climate Observatory (DSCOVR) satellites. GOES, ACE, and DSCOVR data are available from NOAA SWPC. The K_p index was

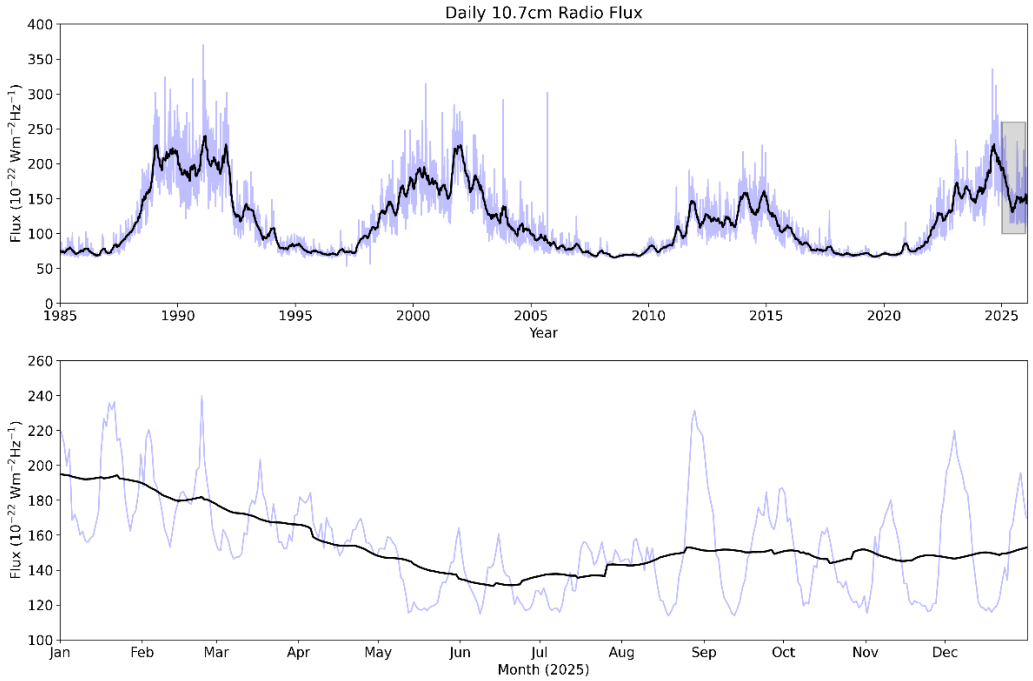


Figure 2: Solar activity over the period 1985-2025 (top panel) and during 2025 (bottom panel, corresponding to the shaded region in the top panel) as measured with the F10.7 cm radio flux, a commonly used activity indicator which is sourced from the Penticton solar radio flux.

provided by the Helmholtz-Zentrum für Geoforschung (GFZ) Potsdam. Solar X-ray flares exceeding moderate and severe thresholds for issuing high frequency (HF) communications (HF COM) advisories for shortwave fadeout were observed in January, February, March, May, June, November, and December. Solar proton enhancements, which can lead to High Frequency Communications advisories for polar cap absorption, were observed in January, February, March/April, May, June, August, and November. K_p enhancements that exceed the moderate and severe thresholds for High Frequency Communications auroral absorption advisories were observed in January (moderate), May (moderate), and November (severe).

A particularly interesting series of events was observed in November 2025, Figure 4. During this event daily X-class solar X-ray flares were observed November 9th – 11th in combination with several solar proton events. The >10 MeV solar proton flux reached peaks of >10 pfu, >100 pfu, and >1000 pfu on November 10, 11, and 12, respectively. The >50 MeV, >100 MeV, and >500 MeV solar proton flux became enhanced on November 11th reaching peaks on November 11th and 12th and elevated radiation levels were observed. The K_p index was enhanced November 12-13, with a peak of K_p=9- during the first 3 hours of November 12th. In response to this activity several advisories were issued (see Figure 5, also discussed in the next Section).

Figure 3. Overview of the solar and geomagnetic activity in 2025. The figure shows from top to bottom: solar X-ray flux (flaring activity), solar proton flux, interplanetary magnetic field, solar wind speed, and K_p index. Solar X-ray flux and solar proton flux are measured near the Earth by the Geostationary Operational Environmental Satellites (GOES) (source NOAA SWPC). Interplanetary magnetic field and solar wind parameters are measured by the Advanced Composition Explorer (ACE) and Deep Space Climate Observatory (DSCOVR) satellites (source NOAA SWPC). The bottom panel shows the geomagnetic activity indicator K_p (source GFZ Potsdam).

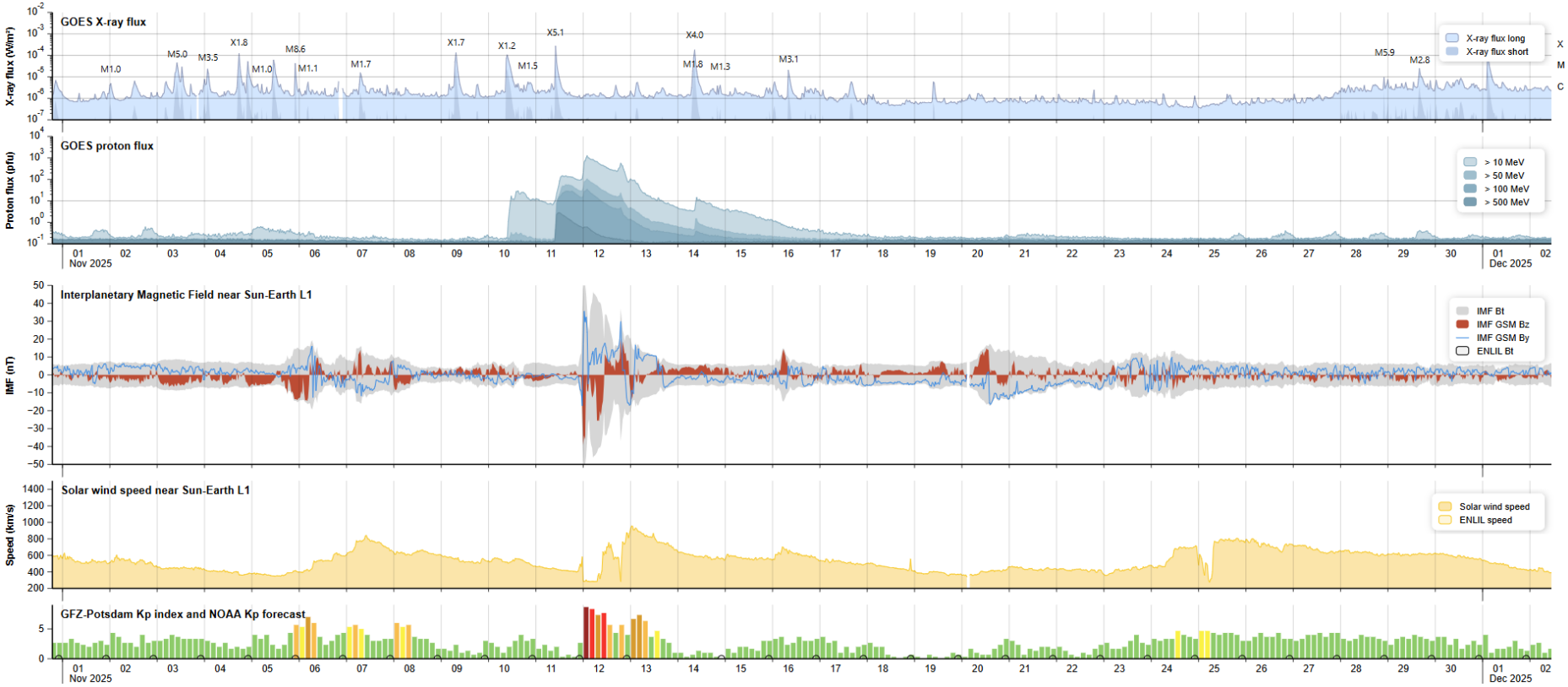


Figure 4. Overview of the solar and geomagnetic activity over 01-30 November 2025. The figure shows from top to bottom: solar X-ray flux (flaring activity), solar proton flux, interplanetary magnetic field, solar wind speed, and K_p index. Solar X-ray flux and solar proton flux are measured near the Earth by the Geostationary Operational Environmental Satellites (GOES) (source NOAA SWPC). Interplanetary magnetic field and solar wind parameters are measured by the Advanced Composition Explorer (ACE) and Deep Space Climate Observatory (DSCOVR) satellites (source NOAA SWPC). The bottom panel shows the geomagnetic activity indicator K_p (source GFZ Potsdam).

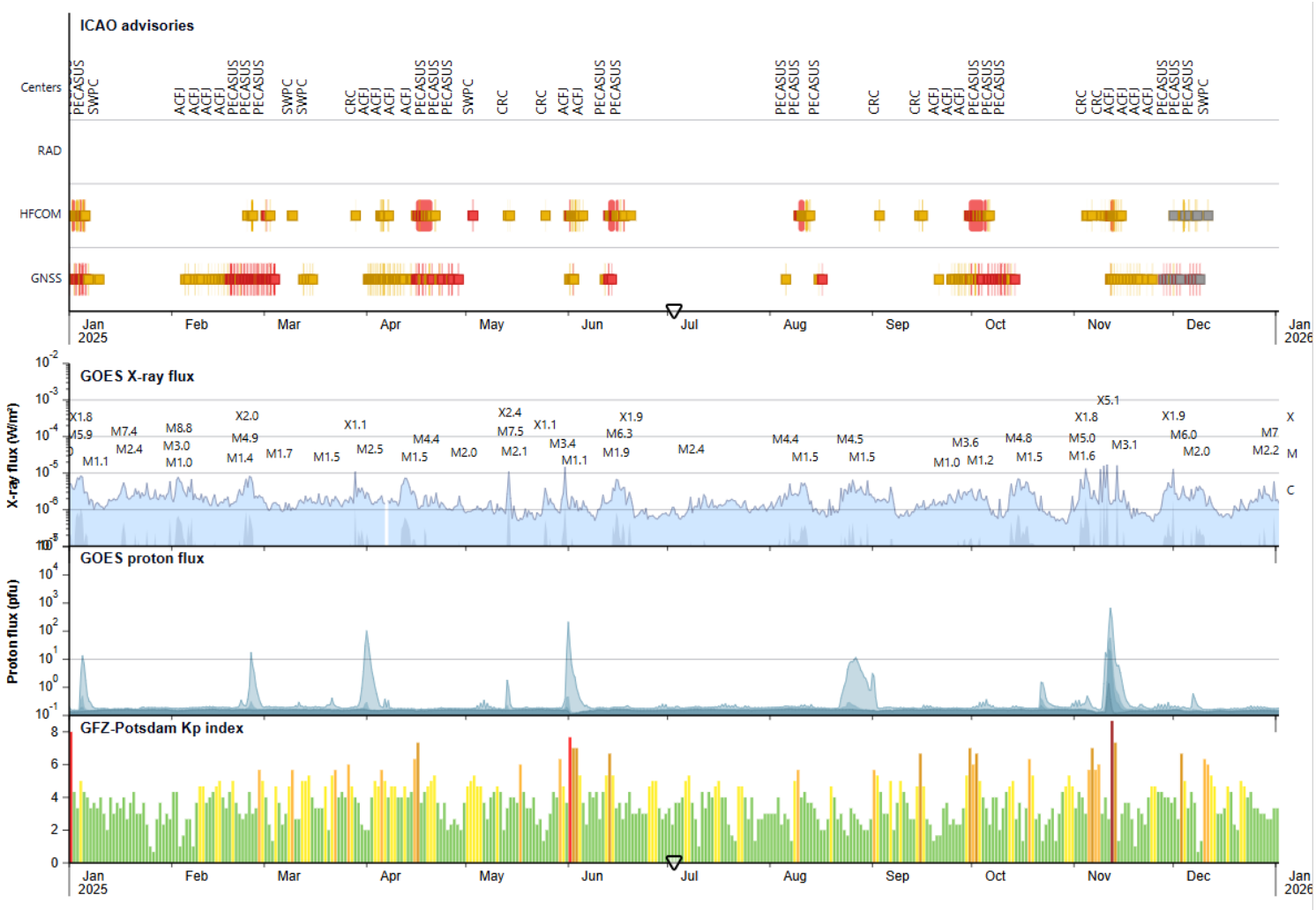


Figure 5. An overlay of when the advisories were issued by each of the SWXCs compared to solar and geomagnetic activity in 2025. The top panel indicates which centres were on duty when RAD, HF COM, and GNSS advisories were issued. Shaded squares and lines show the individual space weather events with yellow representing MOD and red representing

SEV. The second and third panels show the X-ray flare activity and relativistic proton flux which are measured near the Earth by the GOES satellite. The bottom panel shows geomagnetic activity indicator Kp (source GFZ Potsdam). Severe geomagnetic storms were observed in January, June and November (red vertical bars). Beyond 27 November 2025, the viewer was not set up to provide MOD and SEV for the Annex 3 Amendment 82 changes.

2.2 Overview of Advisories Issued Per SWXC Per Effect During the Reporting Period

The information presented in this section is based on an analysis of the SWX advisories issued by the four global SWXCs, as received and analyzed by the Royal Netherlands Meteorological Institute (KNMI) and ACFJ as the lead for the SWIS management report 2025. KNMI is the air navigation service provider for the Netherlands and receives the advisories in its role as an end-user. The ACFJ database is a collection of advisories which have been received through the AFTN, which includes any products issued by ACFJ as they must be received through AFTN to ensure dissemination.

In 2025, the SWXCs issued a total of 738 advisories and 23 test advisories. Table 2 shows a breakdown of the number of advisories issued by each SWXC in 2025 for the different effects: Global Navigation Satellite System (GNSS), High Frequency Communications (HF COM) and Radiation (RAD). The number of events is a measure of how often the thresholds for these three parameters, GNSS, HF COM and RAD, were exceeded. Each event has an initial and a final advisory and updates if applicable. The number of test advisories is shown in round brackets.

Table 2. Number of advisories issued by the SWXCs in 2025 for the different effects and for testing purposes (in round brackets).

	GNSS	HF COM	RAD
ACFJ	223 (1)	95 (1)	0
CRC	0 (1)	24 (1)	0 (6)
PECASUS	211 (2)	169	0 (2)
SWPC	10 (2)	7 (7)	0
Number of Events	179	83	0

Table 2 shows a considerable variation in the number of advisories that are issued by the different SWXCs. The number of GNSS advisories is comparable for ACFJ and PECASUS at >200 advisories, and for CRC and SWPC at <10 advisories. However, there is a strong discrepancy between the two pairs of centres. There is more variation in the number of HF COM advisories, ranging from 169 issued by PECASUS and 7 issued by SWPC. It should be noted that since the start of operations in 2019, no live RAD advisories were issued apart from those issued for test purposes. On 11 November 2025, a GLE (Ground Level Enhancement) occurred. Both the proton flux measured with the GOES highest energy channel (>500 MeV) reached high values (see Figure 4), and the count rate of the ground level neutron monitors reached significant levels. During this event ACFJ was the ODC. Radiation models operated by France and Japan entered ‘GLE mode’ and calculated radiation dose rates. Radiation is modelled in France by the Collecte Localisation Satellites (CLS) using the SiGLE-RT model and in Japan by the National Institute of Information and Communications Technology (NICT) using the Warning System for AVIation Exposure to Solar Energetic particles (WASAVIES) model. Although both models indicated large radiation dose rates that approached the moderate thresholds, criteria for issuing advisories were not reached and no radiation advisory was issued.

Figure 5 shows when the advisories were issued compared to when the space weather events occurred, with yellow representing the moderate events and red representing the severe events.

Several patterns can be observed in this data. HF COM advisories are issued during solar proton events, and during periods of enhanced geomagnetic activity. ACFJ and PECASUS were on duty for the bulk of these periods, which may explain some imbalance in the HF COM advisories. There is a notable pattern in the issuance of GNSS advisories. There are several long periods where GNSS advisories were issued in February/March, April/May, September/October, and November/December. These periods overlap with times when ACFJ and PECASUS were on-duty and consistently transition from moderate to severe as the ODC shifts from ACFJ to PECASUS. These long periods are separated by long periods of few GNSS advisories when SWPC and CRC were on duty.

The variation in the number of advisories issued, illustrated both in Figure 5 and in Table 2, is an observable difference amongst the SWXCs, but it should not be interpreted as evidence that one SWXC is applying the process more correctly that another. In the absence of real-time pilot reports and other operational impact data, there is no validation framework for determining whether a higher or lower number of advisories reflects better performance, better alignment to users impacts, or better adherence to guidance.

Figure 5 also reflects the role of chance for when each SWXC is ODC compared to the activity at the Sun, but there are other factors that contribute to difference in advisories numbers. SWXCs differ in the dissemination and quality control process, which includes the operational staff responsible for the manual review and decision to issue an advisory, and the degree to which those decisions are supported by automation. Differences in the observational data streams and models used to support advisory decisions also contribute to variation.

These factors reinforce the importance of ongoing harmonization work across the SWXCs. For HF COM, SWXCCG sub-team 8 is evaluating the models and measurements used to support advisories related to polar cap absorption and post-storm depression, including analysis of past events and instrument location. For radiation, SWXCCG sub-team 11 is advancing model harmonization efforts and examining the 11 November 2025 ground level event. For GNSS, SWXCCG sub-team 15 is working to better harmonize the threshold criteria, the number, and intensity of advisories issued by global space weather centres. That work includes comparison and sharing of TEC models and scintillation data, as well as investigation of the linkages between scintillation and impacts to satellite-based augmentation systems such as as the Wide Area Augmentation System (WAAS) and the European Geostationary Navigation Overlay Service (EGNOS).

These efforts are important because they will help identify inconsistencies in data sources, models, and operational interpretation, and they will inform future updates to the Guidance for the Issuance of Space Weather Advisories, or the "Cookbook." Between the SWXCCG and sub-teams, there should be ongoing work to establish a robust and shared validation basis grounded in operational impact information. Until such time, the differences in advisory counts should be treated cautiously as they are descriptive, not diagnostic, and they do not by themselves support conclusions about advisory quality or procedural correctness.

To facilitate an optimal use by end-users, there is a need to issue advisories with a minimal latency after a threshold has been exceeded. Figure 6 and Figure 7 show the latency of the GNSS and HF COM advisories issued by the four global SWXCs for the different SWX events (counts). GNSS latency discrepancies are further discussed in Section 2.4. In the future, reducing latency will be important.

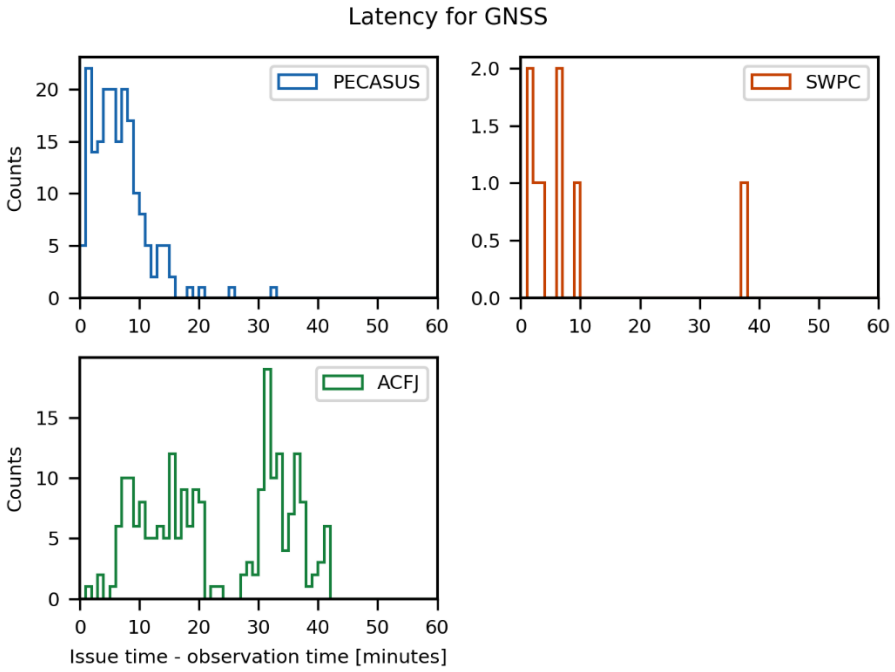


Figure 6. Latency of the GNSS advisories in minutes issued by three SWXCs for the various SWX events (counts). Note: CRC did not issue GNSS advisories.

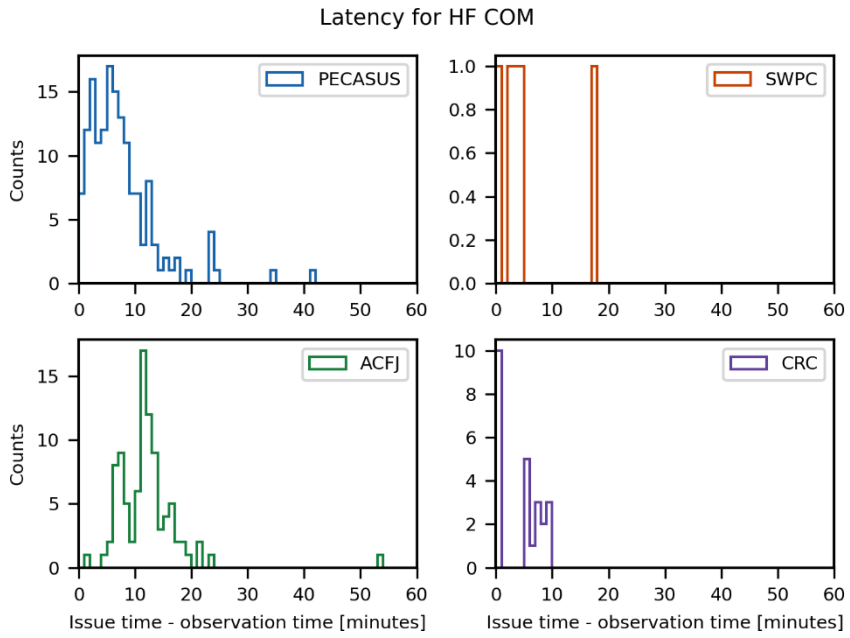


Figure 7. Latency of the HF COM advisories in minutes issued by the four SWXCs for the various SWX events (counts).

Figure 7 and Figure 8 show the impacted areas of the advisories issued by the different SWXCs for HF COM and GNSS, respectively. Figure 7 divides impact area by phenomenon, with the top four plots (one for each centre) representing post storm depression (DEP) and the bottom four plots representing polar cap and auroral absorption (PAA). For PAA, only the high-latitude northern and

southern hemisphere bands were impacted, which is consistent with criteria described in “the Cookbook”. CRC and SWPC did not issue advisories for HF COM PAA as these centres were not on-duty when these phenomena were observed (see Figure 5). GNSS impact areas are shown in Figure 8. For TEC (upper 4 plots), PECASUS, ACFJ, and SWPC all observed enhancements limited to the equatorial region, and CRC did not report any TEC advisories. Scintillation advisories (lower 4 plots) indicated more varied locations, with PECASUS reporting impact areas in 30˚ latitude and 15˚ longitude grid cells at all latitudes, primarily in the northern hemisphere. ACFJ reported impacts across the high-latitude band for all longitudes and for a range of longitudes in the equatorial bands (equally in the northern and southern hemisphere). SWPC reported impact areas in the high latitude northern hemisphere for all longitude bands and in the equatorial northern and southern hemispheres over a large region of South America and the Atlantic Ocean. CRC did not report any scintillation advisories. For both GNSS and HF COM advisories, differences in the region impacted can be attributed to the instrument networks and models that are used by the different SWXCs as inputs to the advisories. To achieve more homogeneous coverage, data exchange of sensor and model data between the SWXCs is important.

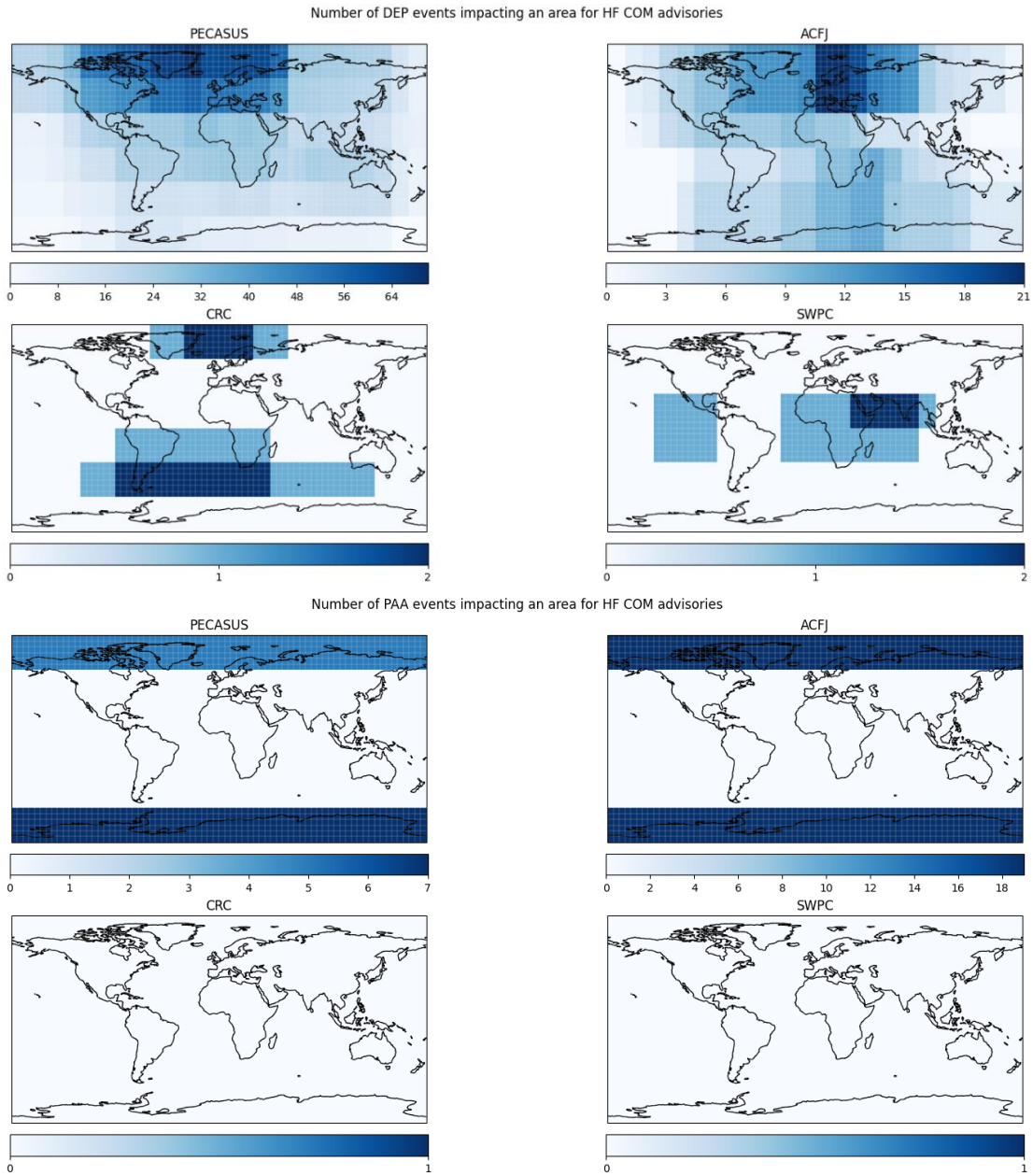


Figure 8: Impact area of HF COM advisories issued by the various SWXCs. Upper and lower panels represent post storm depression (DEP) and polar cap and auroral absorption (PAA), respectively. HF COM PAA advisories were not issued by CRC or SWPC.

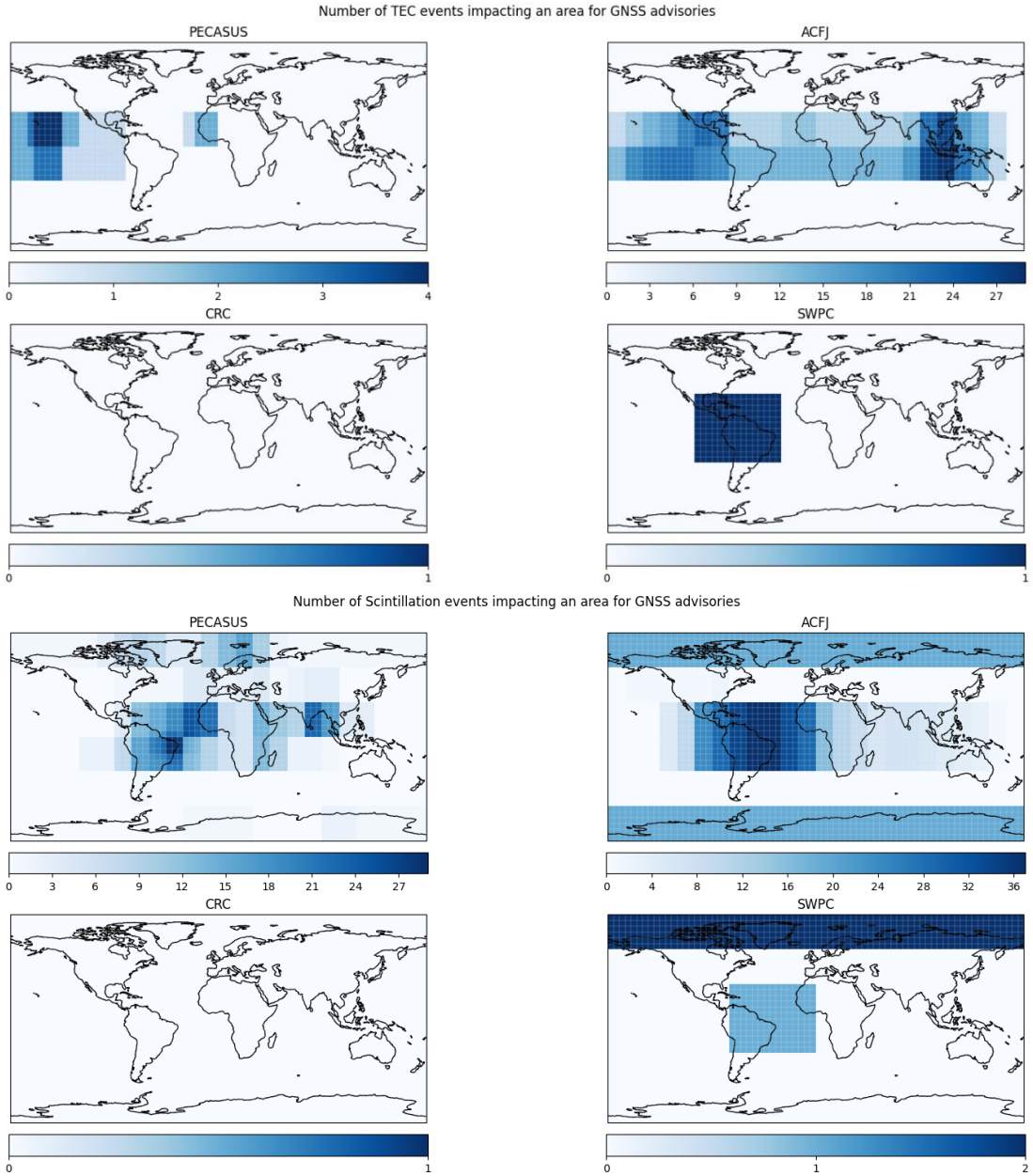


Figure 9: Impact area of GNSS advisories issued by the various SWXCs. Upper and lower panels represent total electron content and scintillation, respectively. Note that CRC did not produce any GNSS advisories

2.3 Findings on the Useability of Advisories

Advisory numbering

SWX advisories are part of the information stream to aviation end-users. Many end-users use automated processing of the information. Automated processing may have been hampered by the following findings in 2025:

- Each SWX event is identified by an initial and a final advisory (NO FURTHER ADVISORIES). However, three final advisories have no replacement number (NR RPLC) and could be interpreted by end-users as a new isolated event.
- One duplicate advisory was issued with the same advisory number and event information.
- Sequence numbers were missed on two advisories, one for GNSS and one for HF COM.
- One advisory was issued and should have had a replacement number as it appeared to be the second advisory in the sequence of advisories issued for a longer event.
- Each effect (GNSS, HF COM, RAD) has its own advisory numbering sequency. Therefore, advisories for different effects can have identical advisory numbers. When these effects occur simultaneously this can be confusing to the end-user.
- Test advisories are part of the SWX numbering sequence for a specific SWX effect. If test advisories are taken out of the processing stream, an end-user will interpret this as a missed advisory.

Advisory forecast information

Advisories are most valuable to end-users when they contain warnings for (possible) future SWX effects. However, the current Standards and Recommended Practices (SARPs) for SWIS in Annex 3 do not *require* forecast information. As a result, the SWX advisories contain, at minimum, nowcast information but in practice many advisories include forecast information. **Error! Reference source not found.** shows the statistics of the 6-hour and 12-hour forecast information. Here 'Detailed forecast' indicates forecast information is available and the region impacted is provided, 'NO SWX EXP' also indicates forecast information is available but MOD or SEV conditions are not expected, and 'NOT AVBL' indicates that information for that period is not available. The 18-hour and 24-hour forecast information is not shown because it contains less relevant information for the end-user and may require further refinement and harmonization of forecast models. For the 6-hour and 12-hour forecasts, forecast information is provided in ~22-25% of the time. To increase these statistics, better meeting user needs, requirements were included in the November 2025 update of "the Cookbook", and it is anticipated that these statistics will improve for 2026.

Table 3: The SWXCs issued 738 advisories in 2025. The table shows the number of advisories with a detailed forecast or an explicit statement that no further SWX impact was expected. The last column shows the number of advisories for which no forecast was available. The rows give the numbers for the 6-hour and 12-hour forecasts.

Forecast period	Detailed forecast	NO SWX EXP	NOT AVBL
6-hour forecast	46	139	553
12-hour forecast	27	138	573

Free text in advisory remarks section

Next to the information contained in the mandatory section of the advisories, SWXCs can provide free text in the remarks (RMK) field of the advisories of up to 256 text characters. Of the 738 advisories, 4 did not contain information in the RMK field (but did not have an entry "NIL"), 2 contained information that was different to the majority of other advisories, and the rest had RMKs

that appeared to use the RMK guidance from the "the Cookbook" used by the SWXCs. In addition, some RMKs provided guidance to users that one event had been finalized but there was still ongoing event under the appropriate advisory number which would direct users to an active advisory. This guidance has also been added into "the Cookbook" for other SWXCs to follow, especially during major events when multiple advisories are issued for different phenomena.

2.4 Results of Key Performance Indicators

KPIs measure the actual performance of the most important aspects of a service and set targets for improving a service. Currently, both timeliness and correct syntax are integrated into the KPIs. A minimal latency is important for informing end-users about ongoing events. Correct syntax is important for automatic and timely processing of advisories.

This report is the consolidated Management Report of the SWIS, so it combines performance information from all SWXCs. Both the KPIs and the Management Report template will evolve and will reflect continuous improvements over time. This consolidated Management Report reflects the fact that solar activity is still at solar maximum during the 2025 reporting period. During future solar minimum, new KPIs may be more appropriate. For example, maintaining operational vigilance of a service during lower activity may require more testing and conducting exercises.

In principle, the KPIs should reflect the requirements for a service as detailed in Appendix A. For this period, the applicable KPIs have been selected by the SWXCCG and are listed below:

- 90% of the advisories must be issued within 15 minutes after the time when the threshold for advisory issuance is met.
- 99% of the advisories that are issued shall have no syntax errors, no numbering errors and permit automated processing by end-users.

It may be clear from Figure 6 that the number of advisories per SWXC varies considerably. In general, 90% of the issued and checked advisories showed a latency of less than 15 minutes. The difference in the observed latency reported by ACFJ and PECASUS has been investigated. The two peaks in the ACFJ latency plots are broadly split by TEC advisories (shorter latency peak) and scintillation advisories (longer latency peak). ACFJ evaluates scintillation over a 15-minute sampling window for collecting scintillation data from detectors. At the end of that window, if an advisory is issued, it is assigned the start-time of the sampling window as the observation time. PECASUS uses a similar method of data collection and evaluation but assigns the end-time of the sampling window as the observation time. ACFJ will implement the same definitions applied by PECASUS and it is expected that the 2026 latency data for ACFJ will be more in-line with PECASUS. It is also noted that different global centres use different types of data for GNSS advisories. These data have different sampling and processing times, which in turn accounts for some of the lack of consistency in the latencies. The low number of advisories issued by SWPC and CRC do not allow a consistent evaluation of the latencies for centres other than ACFJ and PECASUS.

The 99% KPI for the correct format and contents of the advisories implies that of the 738 advisories that were issued about 730 advisories were compliant. Of the non-compliances listed in Section 2.2, 4 advisories were found to be missing a “NR RPLC”, 1 advisory was a duplicate and two advisory numbers were missed. When considering the non-compliances listed above, the KPI for correct

format and contents was above 99% for 2025. If we consider other situations (e.g. where RMK have no wording at all) the KPI for correct format and content would be just below 99% in 2025.

Sub-teams within the SWXCCG are continually working to improve harmonization between SWXCs by developing procedural improvements in 2026.

2.5 Operational Continuity of the Service

For any operational service, continuity is of vital importance. At the time of the audit of the various candidate global SWXCs, this "continuity" requirement was captured in the so-called reliability[2], availability[3] and maintainability[4] requirements for each SWXC. These requirements are listed in Appendix A.

The operations concept that has been implemented has, by design, a high-level of built-in redundancy such that an (almost) 100% continuity of SWIS is ensured. The four global SWXCs perform SWX monitoring and forecasting in two-week shifts with one SWXC serving as the ODC and the others serving as the PBC, the SBC and the MOC.

The SWXCs have a rigorous back-up process, which will occur if the ODC is unable to perform its functions. For unscheduled handovers, the ODC will pass the service to the PBC. This back-up process is intended to ensure that the users receive continuity of service. However, maintaining a record of unscheduled handovers provides a useful record in case users experience issues during these unscheduled handovers.

There were no unscheduled handovers recorded in the reporting period of 2025.

3. FUTURE DEVELOPMENTS AND SERVICE IMPROVEMENTS

Over the coming years, the SWIS will further develop and mature. Toward the end of this decade a Technical Review of the SWIS was anticipated, including a reassessment of the optimal number of global and regional SWXCs. During discussions at the Council 236th Session, it was agreed that the Air Navigation Commission (ANC) will continuously monitor operational efficacy and effectiveness and is no longer required to provide a SWXC 'optimal' number. The means that the ANC will monitor the service, most likely via the SWIS Management Report, and Job Card METP.014 has been updated to remove the requirement for a SWIS technical review. Council acknowledged that the existing coordinated network of global and regional SWXCs deliver a harmonised service essential to aviation safety, that membership of the network remains open to any provider meeting the technical criteria established with WMO, and that a formal assessment of the optimal number of centres is therefore unnecessary. Ongoing monitoring of service provision and effectiveness has been assigned to the Air Navigation Commission.

Over the previous intersessional period, ICAO Council examined the appropriateness and feasibility of a global cost recovery system, including a State Letter canvassing Member State preferences. It

[2] Reliability. The probability of a system or system element performing its intended function under stated conditions without failure for a given period of time.
[3] Availability. The probability that a repairable system or system element is operational at a given point in time under a given set of environment conditions.
[4] Maintainability. The probability that a system or system element can be repaired in a defined environment within a specified period of time.

was found that no consensus could be reached, Council concluded that the outcome did not support a clear path forward. The 42nd ICAO Assembly affirmed this position, and Council at its 236*th* Session formally stated that no further work on a global cost recovery mechanism should be undertaken at this time. It noted that this decision does not preclude individual SWXCs from recovering their costs through existing mechanisms available under ICAO's established charging framework. ICAO's Policies on Charges for Airports and Air Navigation Services (Doc 9082) and supplemented by the Manual on Air Navigation Services Economics (Doc 9161), provide the appropriate and existing framework for cost recovery.

Service improvements are discussed at various levels with the ICAO METP WG-MOG SWX workstream and the SWXCCG and the relevant sub-teams.

The SWXCCG coordinates activities between the different SWXCs, advises the ICAO METP WG-MOG SWX WS on improvements to Annex 3 and PANS-MET provisions, introduces improvements and changes in the SWIS and advisories as approved by the WG-MOG SWX WS. The SWXCCG also maintains the operating procedures for the development of advisories; also known as “the Cookbook” because it contains the “recipe” or “steps” needed to follow when generating the SWX advisories. The SWXCCG also evaluates the satellite data, ground-based data and model data required to produce advisories. This includes harmonization of models and data sets used by all SWXCs as well as recommendations for thresholds when moderate and severe impacts are expected.

The METP WG-MOG SWX WS prepares AMDs to Annex 3 and PANS-MET. In 2025, AMD 82 to Annex 3 and the introduction of the new PANS-MET were applicable as of 27 November 2025. The SWXCs applied the necessary changes to the SWX service and began the gradual transition from latitude/longitude bands to polygons. To ensure consistency of this transition, each space weather phenomenon was progressed independently to ensure each SWXC was able to make technical changes to accommodate polygons. Currently, GNSS and HF COM PAA advisories have been transitioned.

In 2025, the AMD 83 to Annex 3 and AMD 1 to PANS-MET developed by the METP/6 was considered by 230th session of the ANC on 27 November 2025. The ANC authorized its transmission to Member States in 2026. The proposed changes are based on end-user feedback, advice by the SWXCCG on implementation and by members/advisors of the METP WG-MOG SWX WS including experts and representatives of ICAO, the International Federation of Air Line Pilots Associations, the International Air Transport Association, the Federal Aviation Administration and the WMO. Examples of the proposed changes include changing the advisory forecast resolution from +6, +12, +18 and +24 hours to +3, +6, +9 and +12 hours to better address flight planning requirements and forecast model capability. The METP WG-MOG SWX WS also proposed various changes in the ICAO *Manual on Space Weather information in support of International Air Navigation* (Doc 10100, [Reference: RD-2]) for the RAD advisories to improve relevance (noting that as of the publication of this report no valid RAD advisory has been issued). Some longer-term improvements have already been identified and will be included in AMD 84 to Annex 3 and AMD 2 to the PANS-MET which includes the Space Weather Forecast Information to supplement a longer 0 to 48-hour period.

End-user feedback is important to guide the evolution of the service. On 20 October 2025, the SWXCs hosted a Space Weather User Workshop. The event was attended by SWXCCG members, three airlines, the European Organization for the Safety of Air Navigation (EUROCONTROL), NAV

CANADA, ICAO, and IATA. The workshop consisted of a series of presentations providing an overview of the impacts of space weather on aviation and the existing service, and several panels intended to solicit feedback from the community. A summary of the workshop and user feedback was communicated to the METP WG-MOG SWX WS, and a two-day workshop was recommended, and is now being planned for 2026. Based on the user feedback, increased emphasis has been placed on harmonization activities, evaluation of the advisory thresholds, and improved forecast information.

In 2025, the METP WG-MOG WS developed an action for an ad hoc group to consider how the SWIS would transition to a SWIM-enabled service. This work will continue in the coming years.

4. SWXC ACTIVITIES IN 2025

This section consists of brief reports, one from each SWXC, that include concise SWXC-specific information like technical/procedural developments; changes in observations and models; matters related to quality management system (QMS); competency, training and education activities; outreach activities; and relevant research.

ACFJ Report

Technical / procedural developments

- ACFJ-Australia and ACFJ-France completed the implementation of Annex 3 Amendment 82 related to using IWXXM schema 2025-2.
- All consortium members completed software and procedural developments required for the issuance of polygons for the SWXA as planned by the SWXCCG. ACFJ-France and ACFJ-Canada led implementation of the first stage of the polygon upgrade for GNSS, RAD, and HF COM PAA advisories, respectively. ACFJ strongly contributed to discussion amongst the SWXCs and contributed to guidance in “the cookbook”.
- ACFJ-Japan provides high spatial resolution TEC observation information, and reviewed and improved the method for determining representative grid values through consultation within ACFJ.

Changes in observations and models

- ACFJ-Australia updated the international reference ionosphere (IRI) model used for HF post-storm depression advisories by running the IRI-2020 model with storm-time option ON, instead of previously used with this option set to OFF.
- ACFJ-Japan and ACFJ-France improved their radiation models. Japan implemented a mechanism in the WASAVIES (RAD) model to prevent the use of anomalous values in the neutron monitor database. France changed its GCR model in SiGLERT from EPCARD to CARI-7.
- ACFJ-Canada improved their operational network through the deployment of 22 scintillation receivers distributed throughout Canada, and upgraded its geomagnetic alerting system. Canada operates a network of 14 geomagnetic observatories which provide real time data to the automated geomagnetic forecast system with public outputs updated every 15 minutes. Over the last 3 years, efforts were undertaken to modernize the 25-year-old forecast system. In 2025, new software applications were integrated into the operational environment, and the old forecast system was retired.

The software renewal included geomagnetic storm alerting software; the core forecast software which provides outputs for observatory locations, activity zones and regions; graphical outputs for public webpages; and tools used by forecasters to interact with the forecast system. An objective of the modernization was to improve the software security, reliability and maintainability, and enable the development and implementation of new forecast solutions.

Quality management aspects

- ACFJ-France (ESSP) finalised an update to the internal contingency plan and ran a successful contingency test focussed on the scenario of a lack of TEC data availability. A test of the resilience of the GNSS advisory validation system was also successfully carried out simulating a sudden forced restart of the system.
- ACFJ-France (CLS) was audited for the "SWX for Aviation" project as part of the renewal of CLS's ISO 9001:2015 certification.
- ACFJ-Canada and ACFJ-Australia performed internal updates on their standard operating procedures.

Competency, training and educational activities

- ACFJ-Australia began development of a CME modelling course and severe event training as part of ongoing efforts to ensure that new and current forecasters have the most up to date training and competency for space weather forecasting and quality control for ICAO SWXA issuance.
- ACFJ-France (ESSP) led the training of ACFJ forecasters from Australia, Canada, and France on the changes relating to the polygons and IWXXM format. A technical note was also provided to help ACFJ forecasters with the transition. ACFJ-Canada provided its forecasters with a refresher course solar phenomena and Sun-Earth propagation, and provided training on the implementation of polygons for issuing HF COM PAA alerts.

End-user engagement

- ACFJ-Australia hosted the Aviation Meteorological Services – Operations Group in November 2025, providing updates on space weather activity, recent exercises, ICAO Annex 3 ammendment 82 advisory changes, and the transition to polygon-based graphics, as well as delivering the first consolidated management report for the year 2024. ACFJ Australia also continued to support user education and regional exercise planning, including virtually attending the Civil Aviation Augority of New Zealand (CAA NZ) aviation-focused SWX exercise workshop on 28 October 2025 and contributing to scenario design, with outcomes feeding into the National Emergency Management Agency (NEMA) multi-agency exercise Tahu-nui-a-Rangi held 5-6 November 2025.
- ACFJ-Japan, resumed consultation and coordination with domestic government ministries regarding information dissemination, and inputted to domestic government documents. They visited air traffic control operations at the Narita Airport Office and obtained user feedback and information related to operational practices. They also collected information on impacts from domestic user for the November 2025 space weather event, and prepared a Japanese-language version of

the ICAO SWx flyer, disseminated it to domestic users, and publicised it on the NICT website on 11 March 2026. https://swc.nict.go.jp/knowledge/icao.html

- ACFJ-Canada entered a memorandum of understanding with NAV CANADA regarding the provision of space weather services and engaged with national air lines at two NAV CANADA workshops to provide educational information on the ICAO space weather service and to collect user feedback on to improve the development of impact thresholds.

Relevant Research

- All ACFJ centres are collaborating with other SWXCs in the evaluation and harmonization of space weather advisories through the SWXCCG sub-teams. In sub-team 8, Australia is devising a research project in which HF depression advisory thresholds are reviewed to determine if current thresholds remain scientifically defensible and operationally meaningful and Canada, currently the sub-team lead, is performing an evaluation of polar cap absorption models implemented by three of the 4 centres. Japan (leading sub-team 11), with contributions from France, is performing a comparison of SWXC RAD models and coordinating the publication of a related paper. They are also investigating RAD during the November 2025 event. As part of the activities of ICAO Sub-Team 15 and led by France, efforts are being made to compare GNSS advisories, and scintillation data to degradations in SBAS systems such as EGNOS. This analysis aims to inform the strength of the link between GNSS advisories and impacts to SBAS systems seen by users, and hence whether a revision of the thresholds used for GNSS scintillation advisories is needed. France has also led a preliminary study to assess the relevancy of using radio-occultation data to improve the coverage of the scintillation network
- ACFJ-Canada performed a study of ionospheric scintillation activity over Canada and its impact on navigation services and aviation with the goal of linking phase scintillation thresholds to reported impacts (https://doi.org/10.1029/2025SW004360). They also developed an auroral absorption model characterized by geomagnetic activity they will be used to evaluate auroral absorption thresholds for the ICAO service (https://doi.org/10.1029/2025JA034648).

CRC Report

Technical / procedural developments

- In December 2025, the National Satellite Meteorological Center (“NSMC”, also know as National Center for Space Weather) led the development of China’s first-generation “full-link” space weather numerical prediction system (CMA-SWx V1.0), which successfully passed operational acceptance review. CMA-SWx V1.0 provides end-to-end coverage of solar storm propagation through the Sun-Earth system; its integrated Sun-Earth coupling framework enables iterative optimization of inter-layer interactions, thereby significantly improving the prediction of space weather events and supporting operational reliability for communication and navigation systems.
- In July 2025, the world’s first full-chain artificial intelligence forecasting model for space weather, Fengyu, was officially unveiled. It overcomes the technical bottlenecks of conventional numerical models in terms of timeliness and computational efficiency, and represents the first AI-based space weather forecasting model to cover the full chain encompassing the solar wind, magnetosphere, and ionosphere. Over a one-year

performance validation period, Fengyu exhibited strong 24-hour short-range forecasting capabilities across the solar wind, magnetosphere, and ionosphere. Validation results indicate that Fengyu outperforms existing methods in predicting major geomagnetic storms over the past two years. Its performance is particularly remarkable in ionospheric forecasting, with global Total Electron Content (TEC) prediction errors generally controlled within approximately 10%.

- The ICAO Space Weather Intelligent Integrated Application Platform was upgraded to enable automated generation of ICAO space weather advisories. ICAO space weather service products from the China Meteorological Administration (CMA) / Civil Aviation Administration of China (CAAC) are now accessible via mobile applications, with alert dissemination expanded to DingTalk, WeChat, and SMS channels, which greatly improves response timeliness and operational efficiency.
- Advisory generator updated according to Amendment 82 format, both TAC and IWXXM. Grids of all ICAO map products upgraded to 5°×5°. The daily brief has also had minor updates.

Changes in observations and models

- In 2025, Fengyun satellites FY-3H and FY-4C launched with advanced space weather payloads for enhanced early warnings. FY-3H's Ionospheric Photometer improves geomagnetic storm and ionospheric disturbance advisories. On FY-4C, the Solar Extreme UV Imager and high-spectral-resolution X-ray/UV irradiance monitor strengthen HF communication alerts via better solar flare detection, while its ionospheric imager optimizes ionospheric and scintillation monitoring to boost GNSS advisories.
- Three short-term forecasting models for geomagnetic indices Kp, Dst, and ionospheric Total Electron Content (TEC) used in National Center for Space Weather (NCSW) have been upgraded, enhancing 0–12 hour early warning of magnetic storms and ionospheric disturbances.
- Proton energy spectrum evaluation refined in IAG (ROSHYDROMET) Dose Rate Model to improve the evaluation RAD advisories.

Competency, training and educational activities

- Under the CMA innovation team initiative, the youth innovation team "Ionospheric Weather Forecasting and Early Warning Service" was established. The team focuses on ionospheric forecasting and early warning, including multi-source data quality control, data assimilation, and short-term forecasting techniques, to improve operational ionospheric service capabilities.
- In October 2025, the 1st Fengyun Meteorological Satellite International Application Competition concluded. In the Space Weather track, the Sino-Swedish team Group_Lemons developed a multi-satellite Kp index dataset using FY-4B observations. The forecasting model built from this dataset achieved statistically significant performance improvements, especially in forecasting intense geomagnetic storms.
- In 2025, the Civil Aviation Meteorological Center (AMC) of the Air Traffic Management Bureau (ATMB), CAAC, enhanced the collection system for GPS failures and air-ground communication incidents potentially induced by space weather events.
- In November 2025, AMC conducted space weather training for airlines and the communication and navigation departments of the air traffic control system. The training focused primarily on current regulations and standards regarding space weather, the international operational system of space weather centers, and included discussions on

response plans for encountering space weather events.

- A space weather course was held at meteorological service department at ROSHYDROMET. This course is a part of annual aviation meteorologists and users training organized in collaboration with aviation authority.

PECASUS Report

Technical / procedural developments:

- Compliance with AMD 82 & PANS-MET & new IWXXM scheme: Updating the advisory issuance, operational procedures, validation, and archiving tools and developing tools for the transition to polygon-based advisories.
- Establishing automated availability monitoring of internal data sources.
- Improvements of internal alerting systems, steps towards automated advisory area detection, updated data visualization tools and workflows, updates to internal contacts information and products data portfolio

Changes in observations and models:

- Improving the spatial and temporal resolutions of models (e.g. RAD) supporting SWX monitoring
- Adding new data sources and updated models for PECASUS PSD products.
- Adding new stations to the PECASUS GNSS scintillation receiver network.

Quality management aspects:

- Internal service validation and verification tests and audit in April 2025 followed by updates of risk management plan and signings of Service Level Agreements between FMI and other PECASUS partners.
- Activities under SWXCCG and METP/MOG Space Weather working stream: Co-chairing SWXCCG and leading several of its Sub-Teams and Ad Hoc groups. Chairing of the MOG work stream. Active role in the preparations for AMDs 83 and 84 and and for the SWIS transition to become compliant with System Wide Information Management (SWIM) initiative.Support for Management reports: Compilation of the 2024 report and development of open-source tools for statistics and validation of advisories.

Competency, training and educational activities:

- Composing the SWIS Flyer (available in SWXFlyer_4Nov2025_JS_vJan2026.pdf)
- Internal trainings for PECASUS 24/7 operators for AMD82 compliance
- External education: Three space weather introductory courses with a specialized course for aviation sector in May 2025 (https://events.spacepole.be/category/4/);

End-user engagement:

- Workshops: PECASUS WS with KLM operators and dispatchers (Schiphol, Nov 24, 2025) and preparatory work and presentations for the ICAO User workshop (Rome, Nov 20)
- Participation to the NAT SWX2025 tabletop exercise (Dec 10-11, 2025) and
- Annual consultations with national aviation representatives.

Relevant Research:

- Balloon launches with RAD detectors and their data analysis in the context of the GLE#77 event (Nov 11, 2025).
- Research-to-Operations development of new models (MAIRE+, ODRAM) and scintillation model validation with observations.
- Scientific publications and presentations in the European Space Weather Week, UK Space Weather and Spece Environment meeting III, URSI and other relevant meetings.

SWPC Report

Technical / procedural developments:

- Updated Mercury (ICAO Advisory Application) software to draw rectangular polygons and convert them to the latitude band coordinate system.
- Updated Mercury software to draw any 5-point polygon and convert it to the new ICAO coordinate system.
- Updated Mercury software to display geographical model data in an interactive map.

Changes in observations and models:

- Deprecated CTIPe in favor of WAM-IPE for MUF advisories, and GLOTEC for TEC advisories.

Quality management aspects:

- Completed ISO 9001:2015 Surveillance Audit in February 2026 with a “highly effective” rating.

Competency, training and educational activities:

- Trained forecasters on changes to Mercury application.
- Trained forecasters on Cookbook revisions.

End-user engagement:

- **NAT Exercise (10-11 December 2025)**
  - SWPC played a key role in scenario development and execution of an International Civil Aviation space weather-focused Table-Top Exercise (TTX) held 10-11 December 2025. The two-day exercise included broad participation from international and domestic airlines, with most partners convened in Paris, France. SWPC created all the needed advisories, warnings, and alerts for the TTX and participated virtually, providing subject matter expertise and real-time clarification throughout the exercise.
  - The TTX was designed to evaluate how airlines and aviation decision-makers would respond to a series of simulated SWPC space weather warnings and alerts, as well as ICAO advisories, during a significant space weather event. The exercise represented the culmination of extensive preparatory work by SWPC, including developing approximately 22 realistic warnings, alerts, and advisories embedded in a carefully constructed scenario to drive operational decision-making and highlight potential impacts.

- Initial feedback from the aviation community was highly positive. Participants reported increased understanding of the types of products they would receive during a major space weather event and how those products support operational planning and risk mitigation. However, they also conveyed some dissatisfaction with the ICAO style advisories. The number of participating entities, countries, and airlines was large, with more than 100 participants as representatives from 16 countries, 13 carriers, 6 International Organizations, ICAO EUR/NAT, 4 Space Weather Advisory Centers, FAA, NOAA, and more. Questions asked throughout the exercise indicated that the majority of the airlines, centers, organizations either directly receive and use NOAA SWPC space weather warnings/alerts; or confirm information with NOAA SWPC products. There was no negative feedback regarding SWPC warnings and alerts, but it is clear that many aviation users are not using the advisories correctly. For example, most are interpreting the "S: scale as an indicator of radiation and many made unnecessary decisions as a result.

SANSA Report

Technical / procedural developments

- All technical and procedural elements related to the space weather centre have been developed in accordance with the ISO 9001:2015 Quality Management System (QMS) and aligned with the SANSA Risk Registers and Business Continuity Plan. SANSA is officially integrated as a Regional Space Weather Centre (RSWXC) since the test phase ended in November 2025 which coincided with the applicability date for Annex 3 Amendment 82). SANSA provides forecast and near real-time GNSS and HF products. The GNSS products include the African TEC map forecast and nowcast, GNSS amplitude and phase scintillations, Southern Africa TEC and ROTI maps, 3D electron density, ionograms, and foF2 deviations. SANSA is now attending the ICAO-SWXC handover process via Slack every 2 weeks.
- SANSA has implemented a dashboard displaying relevant products for the ICAO Global centres (https://portal.swc.sansa.org.za/dashboard).

Changes in observations and models

- The 3D electron density model is fully operational within the centre and is also available on the SANSA ICAO dashboard portal.

Quality management aspects

- The Space Weather Centre was re-certified ISO 9001:2015 on the 21st of February 2025.
- A formal and approved QMS Internal Audit Programme was rigorously followed where all reports and non-conformances were addressed and retained for continual improvement and knowledge management purposes.

Competency, training and educational activities

- SANSA trained two more space weather forecasters through internal training which was completed June 2025.

Relevant Research:

- Research on high TEC observed over Zambia was published in Advances in Space Research Journal https://doi.org/10.1016/j.asr.2025.03.023
- The space weather products have been presented at a number of conferences and workshops.

Appendix A Requirements for SWXCs

The following ICAO qualification requirements were used for the SWXC selection in 2017 [RD-4].

INSTITUTIONAL criteria
Experience as a designated national space weather information provider
A Quality Management System (Annex 3 – Meteorological Service for International Air Navigation)
Appropriate qualifications of the personnel and an ongoing competency and training program (WMO-No 49, WMO-No 258)
Adherence to all applicable data rights
Procedures to liaison with aviation decision-makers and gather feedback on the space weather information service
Procedures for coordination with other space weather information providers.
A source of funding and adequate level of funding to provide the space weather information service for a period of at least 3 years
OPERATIONAL criteria
24/7 operational capability
A system reliability of 99.9 percent with no single failure exceeding 90 minutes in a 24-hour period.
A system availability of 98.0 percent with no single outage exceeding 4 hours in a 1-year period.
A system maintainability of 95.0 percent for a 2-hour interval.
TECHNICAL criteria

Ability to provide the space weather information service, both near real-time and forecast information, as defined in the draft SARPs for Amendment 78 of ICAO Annex 3 — Meteorological Service for International Air Navigation
Ability to access observations (own observations ad received from other space weather providers) of: i. Coronal mass ejections and high-speed streams; ii. Geomagnetic storms; iii. Solar radiation storms; iv. Solar flares; v. Solar radio bursts; and vi. Ionospheric activity
Ability to produce near real-time and forecast information with the space weather information providers for adjacent areas of responsibility a necessary
Ability to conduct forecast verification and provide verification statistics as service performance indicators
COMMUNICATION/DISSEMINATION criteria
Ability to provide the space weather information service to aviation decision-makers, as defined in the draft SARPs for Amendment 78 of ICAO Annex 3 — *Meteorological Service for International Air Navigation*
Ability to provide a communications system and infrastructure that supports the availability, maintainability, and reliability criteria.
Ability to provide the space weather information service via the following means of dissemination: i. ICAO Aeronautical Fixed Service (AFS); ii. World Area Forecast System Internet File Service (WIFS); iii. Secure Aviation Data Information Service (SADIS); iv. Regional OPMET centres