

**NATIONAL WEATHER SERVICE INSTRUCTION 10-1102  
NOVEMBER 28, 2023**

***Operations and Services***

***Space Weather Services, NWSPD 10-11***

***PROVISION OF SPACE WEATHER SERVICES FOR GLOBAL AVIATION***

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**NOTICE:** This publication is available at: <http://www.nws.noaa.gov/directives/>.

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***SUMMARY OF REVISIONS:*** This is the initial issuance of NWS Instruction 10-1102, *Provision of Space Weather Services for Global Aviation*. The purpose of this procedural directive is to describe the roles and responsibilities of the Space Weather Prediction Center (SWPC) as a designated global Space Weather Center (SWXC) by the International Civil Aviation Organization (ICAO) for the provision of Space Weather Services (SWS) for global aviation.

November 14, 2023

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Analyze, Forecast and Support Office

**Provision of Space Weather Services for Global Aviation**

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**1. General**

This instruction describes the roles and responsibilities of the Space Weather Prediction Center (SWPC) as a designated global Space Weather Center (SWXC) by the International Civil Aviation Organization (ICAO) for the provision of Space Weather Services (SWS) for global aviation.

**2. Background**

Amendment 78 to the International Standards and Recommended Practices, Meteorological Service for International Air Navigation, Annex 3 to the Convention on International Civil Aviation (Amd. 78, Annex 3), adopted by the Council of ICAO on March 7, 2018, introduced basic initial provisions for space weather advisory information services in response to user needs expressed by International Air Transport Association (IATA), as no information of any kind was available to assist operators in assessing the risks associated with space weather events. SWPC is one of four global SWXCs designated by ICAO to provide SWS when necessitated by space weather events as the On-Duty-Center (ODC) on a two-week rotational basis. SWPC also provides backup services to other SWXCs when needed in two-week rotations as primary, secondary and tertiary (maintenance) backup.

**3. Space Weather Centers**

SWXCs are designated to monitor and provide advisory information on space weather phenomena expected to affect high-frequency radio communications, communications via satellite, Global Navigation Satellite Systems (GNSS)-based navigation and surveillance systems, and/or pose a radiation risk to aircraft occupants. There are four SWXCs designated by ICAO: SWPC, Pan-European Consortium for Aviation Space Weather User Services (PECASUS), China-Russia Consortium (CRC), and Australia-Canada-France-Japan (ACFJ).

There are basic requirements for the SWXCs, including but not limited to reliability, sustainability, and connectivity to both the users of the services as well as the inflowing data and observations necessary for the products defined by the ICAO Standards and Recommended Practices (SARPs).

3.1 Aviation products must have a high priority in the formulation and distribution of the required space weather advisory information due to almost immediate effects on aircraft navigation and communication systems as well as radiation impacts to passengers and aircrew.

3.2 The SWXCs are responsible for providing all necessary services to allow for the issuance of space weather advisory information in a timely manner. Specifically, the data and model output must include:

- a. ionospheric scintillation (amplitude and phase), and total electron content (TEC) for GNSS;
- b. effective dose for radiation; and
- c. Auroral Absorption (Kp), Polar Cap Absorption (PCA), Solar X-ray (or equivalent), and Maximum Usable Frequency (MUF) for High Frequency (HF) communications.

3.3 In some cases, physics-based models are envisioned to support the requirements stipulated by SARPs, in particular, for radiation. The SWXCs must have access to the model and be able to provide output from the model as quickly as possible. It is recognized that input data will have some latency, and thus performance requirements will evolve to the cadence of the model-based information being disbursed.

3.4 The SWXCs must be staffed 24 hours a day/7 days a week. Operations personnel are required to keep abreast of the current conditions and disseminate short-term forecasts as defined in the SARPs.

3.5 All SWXCs must develop coordination protocols and procedures to enable clear and unambiguous information disseminated to the aviation industry.

#### 4. Space Weather Impacts to Aviation

The most significant impacts to aviation are noted in the following table:

Phenomena	Impacts
Geomagnetic Storms	Geomagnetic storms perturb the ionosphere to affect HF communications, GNSS navigation in the high latitude regions and sometimes include middle latitude regions. Equatorial regions may be affected during the worst of storms.
Solar Radiation Storms	The increased radiation exposure associated with solar radiation storms is most intense at high latitudes and are usually confined to the high latitude bands. On rare occasions, they could extend into the middle latitude bands. Solar radiation storms may be severe above a certain altitude, and moderate below. Solar Radiation

	storms also affect the HF communications at high latitudes.
Ionospheric Storms	Ionospheric disruptions, caused by scintillation, primarily affect the equatorial and high latitude regions but can also extend into middle latitudes, and may affect GNSS navigation. These perturbations can be more localized than the other space weather events and thus may be best described using latitude and longitude coordinates.
Solar Flare Radio Blackouts	Solar flare radio blackouts degrade communications, and on rare occasions GNSS navigation, and are a daylight side impact only. These events may last from a few minutes to a few hours and are a much shorter duration than geomagnetic storm impacts.

## 5. Space Weather Advisory Product

Amd. 78, Annex 3 introduced a requirement to issue space weather advisory information when necessitated by space weather events. The SWPC, as part of its mission, creates and disseminates space weather alerts, watches, warnings, event summaries, and outlook discussion advisories. In November 2018, the ICAO selected SWPC as one of the four global SWXC to monitor and provide advisory information on space weather phenomena. These phenomena include those that may affect high-frequency radio communications, communications via satellite, GNSS-based navigation and surveillance systems, and/or pose a radiation risk to aircraft occupants.

5.1 SWXCs issue the space weather advisory when impacts to HF communications, communications via satellite, GNSS-based navigation and surveillance systems, or heightened radiation occurs. Updated advisory information on space weather phenomena shall be issued as necessary but updated at least every six hours until such time as the space weather phenomena are no longer detected and/or are no longer expected to have impact.

5.2 The advisory message informs the user of:

- a. the type of impact;
- b. the expected onset, or that the event is already in progress;
- c. the duration of the event;
- d. a generalized description of the spatial extent affected for the next 24 hours; and
- e. a description of the severity of the impact in moderate (MOD) or severe (SEV) categories.

5.3 Thresholds for space weather advisories:

	Moderate	Severe
<b>GNSS</b>		
Amplitude Scintillation (S4)(dimensionless) <sup>1</sup>	0.5	0.8
Phase Scintillation (Sigma-Phi)(radians) <sup>1</sup>	0.4	0.7

Vertical TEC (TEC Units)	125	175
<b>RADIATION</b>		
Effective Dose (micro-Sieverts/hour) <sup>2</sup>	30	80
<b>HF</b>		
Auroral Absorption (Kp)	8	9
OCA (dB from 30 MHz Riometer data)	2	5
Solar X-rays (0.1 - 0.8 nm)(W-m <sup>-2</sup> )	1X10 <sup>-4</sup> (X1)	1X10 <sup>-3</sup> (X10)
Post-Storm Depression (MUF) <sup>3</sup>	30%	50%

<sup>1</sup>Advisories for scintillation (both Amplitude and Phase) are currently based on a subjective interpretation of output from the Rate of TEC Index (ROTI) model. Efforts are underway to pair the model output with ground-based receiver observations to provide a more precise product.

<sup>2</sup>MOD advisories will only be issued when the MOD threshold is reached at FL460 and below. SEV advisories will be issued when the SEV threshold is reached at any flight level.

<sup>3</sup>As compared to a 30-day running median of the critical frequency of the F2 layer (foF2).

## 6. Space Weather Advisory Product Identification

The following are specific World Meteorological Organization (WMO) identifications for Space Weather Advisory products issued by SWXCs. The Space Weather Advisory product is issued in text and ICAO Meteorological Information Exchange Model (IWXXM) form. The space weather advisories will be disseminated in accordance with the provisions in ICAO Annex 3

*Meteorological Service for International Air Navigation* and ICAO Document 10100 *Manual on Space Weather Information in Support of International Air Navigation*. The SWXCs are required to disseminate advisory information to area aeronautical control centers, flight information centers, aerodrome meteorological offices, the other SWXCs, international operational meteorological information (OPMET) databanks, international Notices to Airmen (NOTAM) offices, and aeronautical fixed service Internet-based services.

SWXC	WMO Header (IWXXM Advisory)	WMO Header (TAC Advisory)
ACFJ - Australia	LNXX01 YMMC	FNXX01 YMMC
ACFJ - France	LNXX01 LFPW	FNXX01 LFPW
PECASUS - Finland	LNXX01 EFKL	FNXX01 EFKL
PECASUS - UK	LNXX01 EGRR	FNXX01 EGRR
CRC - China	LNXX01 ZBBB	FNXX01 ZBBB
CRC - Russia	LNXX01 UUAG	FNXX01 UUAG

<b>SWXC</b>	<b>WMO Header (IWXXM Advisory)</b>	<b>WMO Header (TAC Advisory)</b>
ACFJ - Australia	LNXX01 YMMC	FNXX01 YMMC
SWPC - USA	LNXX01 KWNP	FNXX01 KWNP

01 = GNSS, 02 = HF COM, 03 = RADIATION, 04 = SATCOM

## Appendix A – Space Weather Advisory Examples

This appendix contains Space Weather Advisory examples. The most current issue/version of each product in this appendix can be found at <https://tgftp.nws.noaa.gov/data/raw/>

### 1. Space Weather Advisory Product Examples

#### a. GNSS and HF COM Effects

##### SWX ADVISORY

DTG: 20161108/0100Z  
SWXC: SWPC

ADVISORY NR: 2016/2

NR RPLC: 2016/1

SWX EFFECT: HF COM MOD AND GNSS MOD

OBS SWX: 08/0100Z HNH HSH E18000 – W18000

FCST SWX +6 HR: 08/0700Z HNH HSH E18000 – W18000

FCST SWX +12 HR: 08/1300Z HNH HSH E18000 – W18000

FCST SWX +18 HR: 08/1900Z HNH HSH E18000 – W18000

FCST SWX +24 HR 09/0100Z NO SWX EXP

RMK: LOW LVL GEOMAGNETIC STORMING CAUSING INCREASED AURORAL ACT AND SUBSEQUENT MOD DEGRADATION OF GNSS AND HF COM AVBL IN THE AURORAL ZONE. THIS STORMING EXP TO SUBSIDE IN THE FCST PERIOD. SEE [SPACEWEATHER.GOV](https://spaceweather.gov).

NXT ADVISORY: NO FURTHER ADVISORIES

#### b. RADIATION Effects

##### SWX ADVISORY

DTG: 20161108/0000Z

SWXC: SWPC

SWX EFFECT: RADIATION MOD

ADVISORY NR: 2016/2

NR RPLC: 2016/1

FCST SWX: 20161108/0100Z HNH HSH E18000 – W18000 ABV FL350

FCST SWX +6 HR: 20121108/0700Z HNH HSH E18000 – W18000 ABV FL350

FCST SWX +12 HR: 20161108/1300Z HNH HSH E18000 – W18000 ABV FL350

FCST SWX +18 HR: 20161108/1900Z HNH HSH E18000 – W18000 ABV FL350

FCST SWX +24 HR: 20161109/0100Z NO SWX EXP

RMK: RADIATION LVL EXCEEDED 100 PCT OF BACKGROUND LVL AT FL350 AND ABV. THE CURRENT EVENT HAS PEAKED AND LVL SLW RTN TO BACKGROUND LVL. SEE [SPACEWEATHER.GOV](https://spaceweather.gov)

NXT ADVISORY: NO FURTHER ADVISORIES

**c. HF COM Effects**

SWX ADVISORY  
DTG: 20161108/0100Z  
SWXC: SWPC  
SWX EFFECT: HF COM SEV  
ADVISORY NR: 2016/1  
OBS SWX: 20161108/0100Z DAYLIGHT SIDE  
FCST SWX +6 HR: 20121108/0700Z DAYLIGHT SIDE  
FCST SWX +12 HR: 20161108/1300Z DAYLIGHT SIDE  
FCST SWX +18 HR: 20161108/1900Z DAYLIGHT SIDE  
FCST SWX +24 HR: 20161109/0100Z DAYLIGHT SIDE  
RMK: PERIODIC HF COM ABSORPTION OBS AND LIKELY TO  
CONT IN THE NEAR TERM. CMPL AND PERIODIC LOSS OF  
HF ON THE SUNLIT SIDE OF THE EARTH EXP. CONT HF  
COM DEGRADATION LIKELY OVER THE NXT 7 DAYS.

SEE  
[SPACEWEATHER.GOV](http://SPACEWEATHER.GOV)  
NXT ADVISORY: 20161108/0700Z

## Appendix B – Space Weather Acronyms

This appendix contains frequently used acronyms or units of measurement used in Space Weather. A space weather glossary is located at <http://www.swpc.noaa.gov/content/space-weather-glossary>.

**ACFJ** - Australia-Canada-France-Japan

**COM** - Communications

**CRC** - China-Russia Consortium

**GNSS** - Global Navigation Satellite Systems

**HF** - High Frequency

**HNH** - High Latitude Band

**HSH** - High Latitude Band

**ICAO** - International Civil Aviation Organization

**IWXXM** - ICAO Meteorological Information Exchange Model

**Kp** - Auroral Absorption

**MNH** - Middle Latitude Band

**MOD** - Moderate

**MSH** - Middle Latitude Band

**MUF** - Maximum Usable Frequency

**NOTAM** - Notice to Air Mission

**ODC** - On-Duty Center

**OPMET** - International Operational Meteorological Information

**PCA** - Polar Cap Absorption

**PECASUS** - Pan-European Consortium for Aviation Space Weather User Services

**SARP** - Standard and Recommended Practices

**SEV** - Severe

**SWPC** - Space Weather Prediction Center

**SWS** - Space Weather Services

**SWX** - Space Weather

**SWXC** - Space Weather Center

**TAC** - Traditional Alphanumeric Codes

**TEC** - Total Electron Content

**WMO** - World Meteorological Organization