



ICAO

INTERNATIONAL CIVIL AVIATION ORGANIZATION

A UN SPECIALIZED AGENCY

ICAO SPACE WEATHER WORKSHOP

*ICAO Eastern and Southern African & ICAO
Western and Central African Offices*

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Space Weather(SWx) Advisory Information

- **Space Weather Centre (SWXC)**
- **Space Weather Advisory Information**
- **Space Weather Advisory Thresholds**
- **Examples of Space Weather Advisories**
- **Accuracy goals for SWx advisories**
- **Q & A**

SWXCs

ICAO Doc 10100 §3.1 refers.

The SWx information and services required for safe and efficient aircraft operations will be provided by **Designated Global Centres** assisted by **Regional Centres** passing relevant information *to the global centres* for **dissemination**.

The working principle for the centres is to provide space weather advisory information that users can employ for decision-making.



Approved by and published under the authority of the Secretary General.

INTERNATIONAL CIVIL AVIATION ORGANIZATION

Global/Regional Space Weather Centres

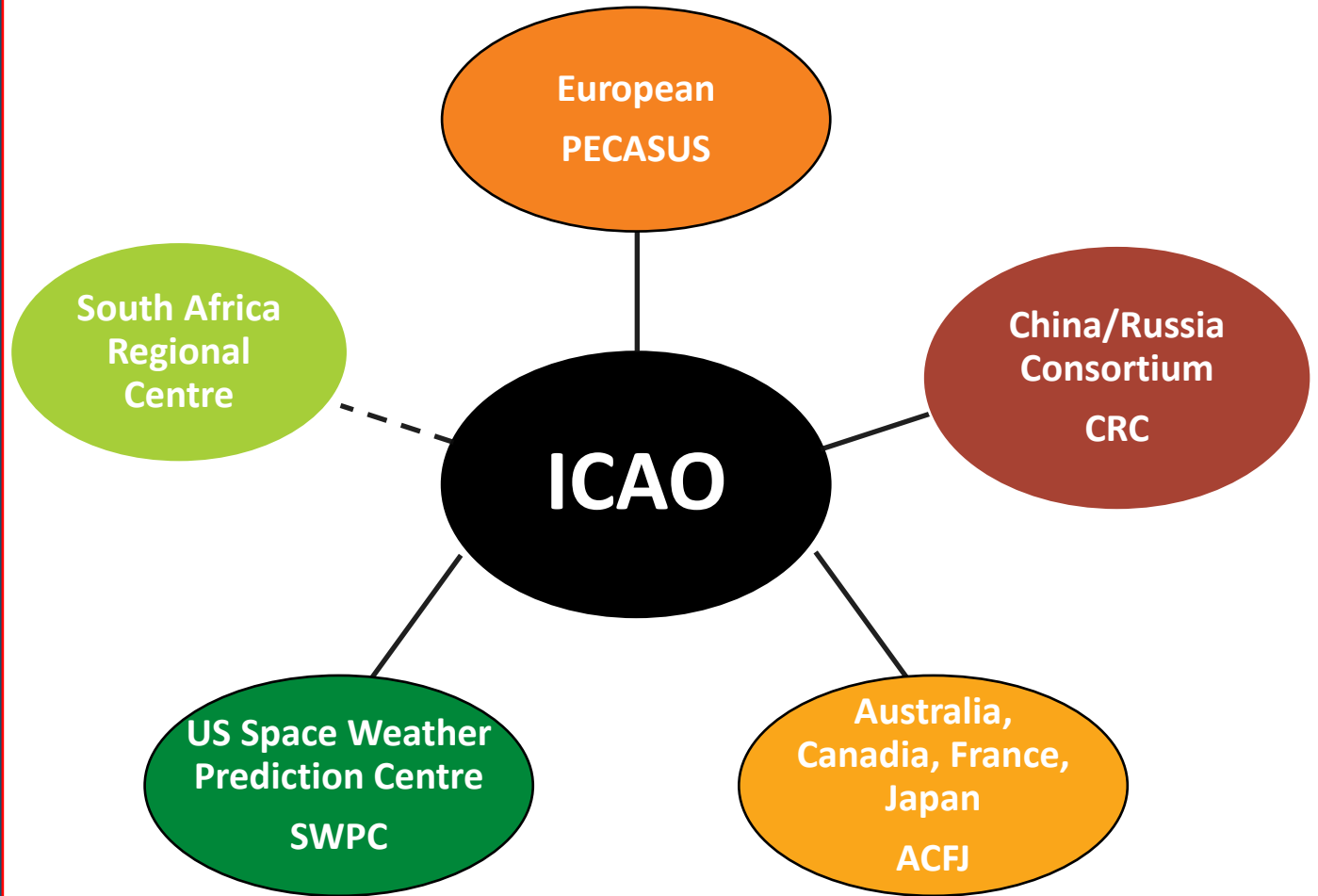
ICAO Council Decision 215/7 (13 Nov. 2028) on the designation of provider States of space weather information, the space weather information service to support international air navigation is expected to be implemented on 7 November 2019 through :

Three global space weather centres :

- PECASUS consortium (Finland as Lead, Belgium, UK, Poland, Germany, Netherlands, Italy, Australia, and Cyprus)
- United States of America
- ACFJ consortium (of Australia, Canada, France and Japan)
- China/Russian Federation consortium.

Two regional space weather centres :

- South Africa, and



Requirements for the provision of SWx information

3.8.1 STD - A Contracting State, having accepted the **responsibility for providing a space weather centre (SWXC)**, shall **arrange for that centre to monitor and provide advisory information on space weather phenomena** in its **area of responsibility** by arranging for that centre to:

- a) monitor relevant ground-based, airborne and space-based observations to detect, and predict when possible, the existence of space weather phenomena that have an impact in the following areas:
 - **High frequency (HF)** radio communications;
 - **Communications via satellite**;
 - **GNSS-based navigation and surveillance**; and
 - **Radiation exposure** at flight levels;
- b) **issue advisory information** regarding the extent, severity and duration of the space weather phenomena that have an impact referred to in a);
- c) **supply the advisory information** referred to in b) to:
 - **ACC/ FIC and Aerodrome meteorological offices** in its area of responsibility which may be affected;
 - 2) other **SWXCs**; and
 - 3) **International OPMET databanks**, international NOTAM offices and **Aeronautical Fixed Service Internet-based services**.

3.8.2 STD - **SWXC shall maintain a 24-hour watch.**

3.8.3 In case of interruption of the operation of a SWXC, its functions shall be carried out by another SWXC as designated by the SWXC Provider State concerned



AMD 78 to A3
(METP/2)
&
AMD 79 to A3
(METP/4)

A3 App.2 : §6.11
Space Weather
Advisory
Information

Space weather advisory information

- *6.1.1 Recommendation.— Advisory information on space weather should be issued in abbreviated plain language, using approved ICAO abbreviations and numerical values of self-explanatory nature, and should be in accordance with the template shown in Table A2-3. When no approved ICAO abbreviations are available, English plain language text, to be kept to a minimum, should be used.*
- **6.1.2 Recommendation.**— *As of 7 November 2019 and until 4 November 2020, space weather advisory information should be disseminated in IWXXM GML for, in addition to the dissemination of space weather advisory information in abbreviated plain language in accordance with 6.1.1.*
- **6.1.2 STD** - *As of 5 November 2020, space weather advisory information shall be disseminated in IWXXM GML form, in addition to the dissemination of this advisory information in abbreviated plain language in accordance with 6.1.1*

Annex 3 refers to **thresholds of space weather activity** that trigger an advisory.

As much as possible, the principle used to define these thresholds **is based on impacts to systems** rather than **phenomenological severity**.

Categories are listed as **moderate** or **severe**, as referenced in the Space Weather Advisory in Annex 3.

Table 3-1 is a list of thresholds for the various types of space weather events affecting aviation.

Space Weather Events	Moderate	Severe
GNSS		
Amplitude Scintillation (S4)(dimensionless)	0.5	0.8
Phase Scintillation (Sigma-Phi)(radians)	0.4	0.7
Vertical Total Electron Content (TEC Units)	125	175
RADIATION		
Effective Dose (micro-Sieverts/hour) *	30	80
HF		
Auroral Absorption (Kp = 3 hours planetary index of geomagnetic activities)	8	9
Polar Cap Absorption (dB from 30MHz Riometer data)	2	5
Solar X-rays (0.1 - 0.8 nm)(W-m-2)	1X10-4 (X1)	1X10-3 (X10)
Post-Storm Depression (MUF)**	30%	50%

Definitions and spatial ranges for SWXA messages

Geomagnetic Storms

- Geomagnetic storms disturb the ionosphere to affect HF Communications and GNSS navigation in the high latitudes (high latitudes northern hemisphere (HNN) and high latitudes southern hemisphere (HSH)) regions and sometimes include middle latitude (middle latitudes northern hemisphere (MNN) and middle latitudes southern hemisphere (MSH)) regions.
- Equatorial regions (equatorial latitudes northern hemisphere (EQN) and equatorial latitudes southern hemisphere (EQS)) may be affected during the worst storms.
- Combinations of latitude bands include:
 - a) HNN and HSH
 - b) HNN, HSH, MNN and MSH
 - c) EQN and EQS
 - d) MNN, MSH, EQN and EQS

Note.1.— A single band (e.g. HNN) would not be used for geomagnetic storms since both poles are affected.

Note.2.— Altitudes (e.g. ABV FLnnn) are not used

Title of the latitude bands	Ranges of the latitude bands
High latitudes northern hemisphere (HNN)	N90 to N60
Middle latitudes northern hemisphere (MNN)	N60 to N30
Equatorial latitudes northern hemisphere (EQN)	N30 to equator
Equatorial latitudes southern hemisphere (EQS)	Equator to S30
Middle latitudes southern hemisphere (MSH)	S30 to S60
High latitudes southern hemisphere (HSH)	S60 to S90



Definitions and spatial ranges for SWXA messages

Ionospheric Storms

- **Ionospheric disruptions**, caused by scintillation, **primarily affect the equatorial and high latitude regions** but can also **extend into the middle latitudes**. In any case they may **affect GNSS navigation**.
- These disturbances can be more localized than other space weather events and thus may be best described using latitude and longitude coordinates. **They can also be described using longitude lines and one or more of the latitude bands.**
- **Altitude levels** (e.g. ABV FLnnn) **ARE NOT USED**.
- **Combinations include:**
 - a) **a four-sided polygon using four latitude and longitude coordinates;**
 - b) **one or more latitude bands coupled with two lines of longitude, such as:**
 - 1) EQN Wnnn(nn) or Ennn(nn) – Wnnn(nn) or Ennn(nn) EQS Wnnn(nn) or Ennn(nn) – Wnnn(nn) or Ennn(nn)
 - 2) EQN EQS Wnnn(nn) or Ennn(nn) – Wnnn(nn) or Ennn(nn)
 - 3) MNH EQN Wnnn(nn) or Ennn(nn) – Wnnn(nn) or Ennn(nn)
 - 4) MSH EQS Wnnn(nn) or Ennn(nn) – Wnnn(nn) or Ennn(nn)

Definitions and spatial ranges for SWXA messages

Solar radiation storms

- Solar radiation storm impacts **are most intense at high latitudes** and **are usually confined to the HNH and HSH latitude bands**. On rare occasions they could extend into the MNH and MSH.
- Solar radiation **may be severe above a certain altitude** (i.e. flight level (FL)) and **moderate below**.
 - **Example**, SEV ABV FL340, MOD FL250-340, which will require two advisories.
- When two advisories are issued for the same area, it is important that the **other advisory's number and intensity be stated in the remarks section**.
 - **Example**, an advisory for MOD radiation from FL250-340 would include in the remarks "SEE SWX ADVISORY NR 2018/7 FOR SEV RADIATION ABV FL340".

Definitions and spatial ranges for SWXA messages

Solar radiation storms

Radiation storms are the **only events that will use altitudes**, i.e. **ABV**
FLnnn.

Combinations include:

- HNH and HSH E18000 – W18000 ABV FLnnn
- MNH and MSH E18000 – W18000 ABV FLnnn
- EQN and EQS E18000 – W18000 ABV FLnnn
- HNH, HSH, MNH and MSH E18000 – W18000 ABV FLnnn
- HNH, HSH, MNH, MSH, EQN and EQS E18000 – W18000 ABV FLnnn
- HNH and HSH E18000 – W18000 FLnnn–nnn
- MNH and MSH E18000 – W18000 FLnnn–nnn
- EQN and EQS E18000 – W18000 FLnnn–nnn
- HNH, HSH, MNH and MSH E18000 – W18000 FLnnn–nnn
- HNH, HSH, MNH, MSH, EQN and EQS E18000 – W18000 FLnnn–nnn

- As per Attachment E to Annex 3, the range for the flight levels is from FL250 to FL600, with a resolution of 30, i.e. 3 000 feet.
- Usable flight levels for the advisory are: FL250, FL280, FL310, FL340, FL370, FL400, FL430, FL460, FL490, FL520, FL550, and FL580.

WMO Headers for Advisories

The WMO message headers (TTAAii CCCC) for space weather advisories in Traditional Alphanumeric Code (TAC) and in ICAO Weather Exchange Model (IWXXM)

	WMO Headers	
	TAC Advisory	IWXXM Advisory
ACFJ – Australia	FNXX01 YMMC	LNXX01 YMMC
ACFJ – France	FNXX01 LFPW	LNXX01 LFPW
PECASUS – Finland	FNXX01 EFKL	LNXX01 EFKL
PECASUS – UK	FNXX01 EGRR	LNXX01 EGRR
CRC – China	FNXX01 ZBBB	LNXX01 ZBBB
CRC – Russia	FNXX01 UUAG	LNXX01 UUAG
SPWC – USA	FNXX01 KWNP	LNXX01 KWNP

Source FAA

01 = GNSS

02 = HF COM

03 = RADIATION

04 = SATCOM

Space Weather Advisory Messages

SWXA Message Format – Reference to A3, Table A2-3. Template for advisory message for space weather information

Message Structure

WMO header

The World Meteorological Organization header is included to facilitate the international exchange of messages.

Message type

The message type is identified as SWX (space weather) ADVISORY.

SWX ADVISORY

Status indicator

Indicator of test or exercise.

TEST or EXER

Time of origin

Year, month, day and time of issue followed by the letter Z (universal time coordinated, UTC).

DTG: 20161108/0100Z

Name of SWXC

The name of the Space Weather Centre.

SWXC: DONLON*

Advisory number

Year in full and unique message number.

ADVISORY NR: 2016/2

Number of advisory being replaced

Number of the previously issued being replaced.

NR RPLC: 2016/1

Space weather effect & intensity

Effect and intensity of the space weather phenomena.

SWX EFFECT: GNSS MOD

Observed or expected space weather phenomena

Day and time (UTC) of observed phenomena (or forecast if phenomena have yet to occur).

Horizontal extent (latitude bands and longitude in degrees) and/or altitude of space weather phenomena.

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

Forecast of the phenomena (+6 HR)

Day and time (UTC) (6 hours from the time given in Item 8, rounded to the next full hour).

Forecast extent *and/or* altitude of the space weather phenomena for the validity period.

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

Forecast of the phenomena (+12 HR)

Day and time (UTC) (12 hours from the time given in Item 8, rounded to the next full hour).

Forecast extent *and/or* altitude of the space weather phenomena for the validity period.

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

Forecast of the phenomena (+18 HR)

Day and time (UTC) (18 hours from the time given in Item 8, rounded to the next full hour).

Forecast extent *and/or* altitude of the space weather phenomena for the validity period.

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

Forecast of the phenomena (+24HR)

Day and time (UTC) (24 hours from the time given in Item 8, rounded to the next full hour).

Forecast extent *and/or* altitude of the space weather phenomena for the validity period.

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

Remarks

Remarks, as necessary.

RMK: LOW LVL GEOMAGNETIC STORMING CAUSING INCREASED AURORAL ACT AND SUBSEQUENT MOD DEGRADATION OF GNSS AVBL IN THE AURORAL ZONE. THIS STORMING EXPTO SUBSIDE IN THE FCST PERIOD. SEE WWW.SPACEWEATHERPROVIDER.WEB

Next advisory

Year, month, day and time in UTC.

NXT ADVISORY: NO FURTHER ADVISORIES

Examples of Space Weather Advisories

A3 Chap.3, App. 2
Table A2-3.
Template for
advisory message
for space weather
information

Space weather advisory message : **GNSS and HFCOM effects**

(Communication Header)

SWX ADVISORY DTG:	20161108/0100Z
SWXC:	DONLON*
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 WWW.SPACEWEATHERPROVIDER.WEB
NXT ADVISORY :	NO FURTHER ADVISORIES

Examples of Space Weather Advisories

A3 Chap.3, App. 2

Table A2-3.
Template for
advisory message
for space weather
information

Space weather advisory message : **RADIATION** effects

(Communication Header)

SWX ADVISORY DTG: 20161108/0000Z
 SWXC: DONLON*
 ADVISORY NR: 2016/2
 NR RPLC: 2016/1
 SWX EFFECT: RADIATION MOD
 FCST SWX: 08/0100Z HNH HSH E18000 – W18000 ABV FL 350
 FCST SWX +6 HR: 08/0700Z HNH HSH E18000 – W18000 ABV FL 350
 FCST SWX +12 HR: 08/1300Z HNH HSH E18000 – W18000 ABV FL 350
 FCST SWX +18 HR: 08/1900Z HNH HSH E18000 – W18000 ABV FL 350
 FCST SWX +24 HR: 09/0100Z 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 WWW.SPACEWEATHERPROVIDER.WEB
 NXT ADVISORY: NO FURTHER ADVISORIES

Accuracy goals for SWx advisories

The accuracy of SWx advisories is affected by several factors

- A key difference between terrestrial and space weather forecasts : **Vast volume of space** and the **sparse data available** to space weather forecasters.
- **It is difficult for space weather forecasters** to provide long-term forecasts.
- The space weather system is **extensive** and **data collection is sparse**.
- Need of **improved forecasts skills** occur. WMO has begun on a **training and capacity building framework for space weather** in line with the WMO Guide to Competency (WMO-1205). In this way, **training and capacity building management for space weather will be aligned with common practices for meteorological staff**.
- Space weather advisories **are subject of validation and verification**. Various metrics are used for this purpose, including metrics used in conventional meteorology such as :
 - **Reliability diagrams**
 - **Contingency tables** and traditional metrics, such as **Probability of detection (POD)**, **false alarm rate (FAR)**, etc.



Thank You!