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# Guidance on Space Weather requirements Workshop

*(Virtual, 28-29 July 2021)*

## Space Weather Information to Users

*(Presented by Goama Ilboudo, Regional Officer, MET, WACAF Office)*





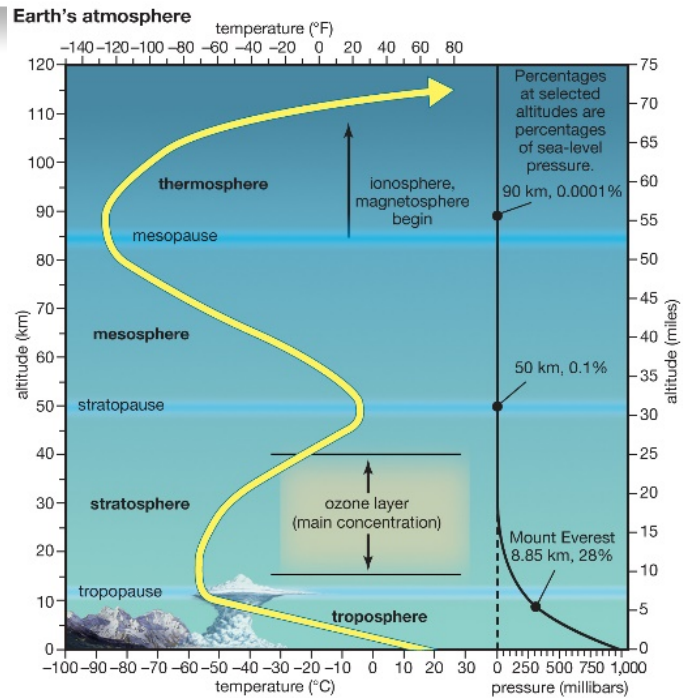
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# Overview on Space Weather



# What is Space Weather ?



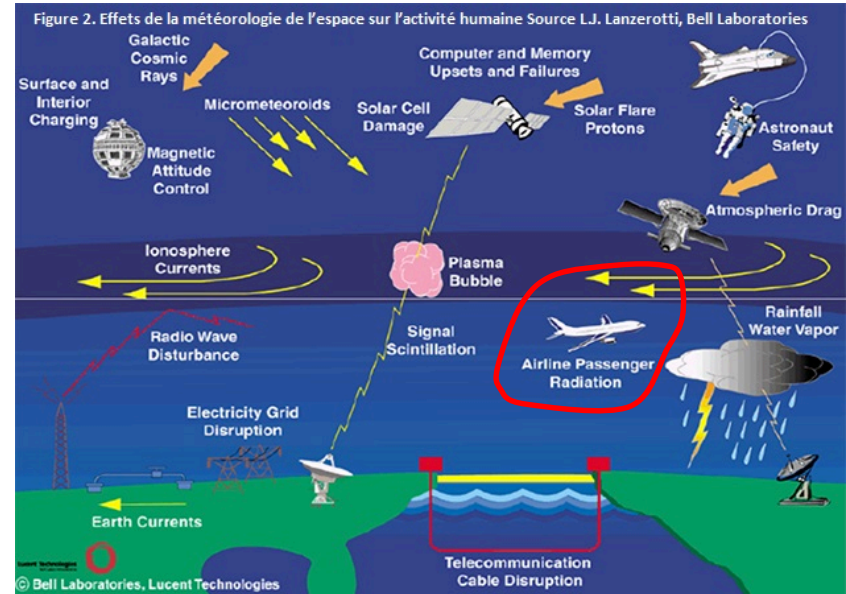
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**The ionosphere :** The layer of the earth's atmosphere which contains a high concentration of ions and free electrons and is able to reflect radio waves. It lies above the mesosphere and extends from about 80 to 1,000 km above the earth's surface.

- Space weather can be described as the solar activity on the surface of the sun creating certain atmospheric events that can affect us here on earth.
  - These environmental conditions are important for us to monitor as they can affect the performance and reliability of our satellites, navigation systems and radio communications. Those flying at high altitudes are also at risk of increased radiation exposure.
- The effects of space weather events can last anywhere from a few seconds to a number of days.
  - Space weather forecasts for international air navigation address particular types of disturbances such as solar radiation storms, geomagnetic storms, ionospheric storms and solar flares.
  - These forecasts enable operators to maintain awareness of potential hazards and to formulate alternative plans should the impending conditions be of a magnitude and/or type that could disrupt normal operations

# SWX impacts

- **HF Communications impacts caused by solar flare**
  - **No advance warning**
  - Effects lasts for **10's of minutes to several hours**
  - **Impacts HF communication** on the sunlit side of the Earth
- **Radiation:**
  - **Warnings possible** on the minutes to hours time scale
  - Elevated levels can persist for several days
  - **Impacts High Frequency communication** in the polar regions, affecting commercial airline operations
- **Global Navigation Satellite System (GNSS):**
  - **Advance notice possible** given coronal mass ejection (CME) transit times from Sun to Earth range from just under a day to several days
  - In extreme storms, **impacts to power grid operations and stability**
  - **Driver of aurora**; severe to extreme storms may cause aurora to be visible over most of the mid-latitudes





**Many contributors** to the overall space weather risk mitigation system such as ::

- Aeronautical information services (**AIS**);
- Air Traffic flow management (**AFTM**) units;
- **Surveillance and communication** providers;
- **Aeronautical Meteorology Units**
- **Operators**;
- **States**, Civil aviation authorities (**CAA**); and
- **SWXC**.

**Their cooperation in assessing, coordinating and providing information relevant for pre-flight and in-flight decision making is essential** for effective mitigation of any potential impacts from a space weather event.

**Information on the procedures** of these units in respect to operations in areas forecast to be affected by space weather is available in the following ICAO publications::

- **Annex 3** — Meteorological Service for International Air Navigation
- **Annex 10** — Aeronautical Telecommunications
- **Annex 15** — Aeronautical Information Services
- Doc 9377 – Manual on Coordination between Air Traffic Services, Aeronautical Information Services, and Aeronautical Meteorological Services
- Doc 8896 Manual of Aeronautical Meteorological Practice
- **Doc 10100** – Manual on Space Weather information



# What are ICAO designated SWXCs ?





**Annex 3:Chap.3 refers** . The SWXCs are designated to monitor and provide advisory information on space weather phenomena in real time 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:
  - 1) high frequency (HF) radio communications;
  - 2) communications via satellite;
  - 3) GNSS-based navigation and surveillance; and
  - 4) 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:
  - 1) ACC/ FIC and Aerodrome Meteorological offices (AMO) 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.





# WHO are the Users of SWXCs' services?

The SWXC support a broad user base. These users typically include :

- Electric power entities;
- Satellite operators;
- Emergency managers; and
- A myriad of other interested parties.
- **Aviation products: must have a high priority** in the formulation and distribution of the required space weather advisory information due **to the almost immediate effects on aircraft navigation** and **communication systems** as well as **radiation impacts** to passengers and aircrew.





# Space Weather Advisories



- The space weather advisory message **is similar** in structure to advisory messages for tropical cyclones and volcanic ash clouds issued by the tropical cyclone and volcanic ash advisory Centres concerned.
- Space weather service would include advisories for space weather events affecting, or expected to affect, **Communications, GNSS-based navigation and Surveillance Systems** and pose a **Radiation risks** to flight crew members and passengers within the next 24 hours..
- 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.
- The space weather advisory uses the spatial ranges and resolutions as shown in Annex 3, Attachment E.



## Space Weather Definitions

Code	Definition
SWX	Space Weather
SWXC	Space Weather Centre
HF COM	High frequency communications (propagation, absorption)
SATCOM	Communications via satellite (propagation, absorption)
GNSS	Global navigation satellite system-based navigation and surveillance (degradation)
RADIATION	Radiation at flight levels (increased exposure)
HNH	High latitudes northern hemisphere
MNH	Middle latitudes northern hemisphere
EQN	Equatorial latitudes northern hemisphere
EQS	Equatorial latitudes southern hemisphere
MSH	Middle latitudes southern hemisphere
HSH	High latitudes southern hemisphere

## Spatial Ranges and Resolution

Element to be forecast	Range	Resolution	
Flight level affected by radiation	FL250 – FL600	30	
Longitudes for advisories (degrees)	000° – 180° (E&W)	15	
Latitudes for advisories (degrees)	00° – 90° (N&S)	10	
Latitude bands for advisories (degrees and minutes)	High latitudes northern hemisphere (HNH)	N9000 – N6000	30
	Middle latitudes northern hemisphere (MNH)	N6000 – N3000	
	Equatorial latitudes northern hemisphere (EQN)	N3000 – N0000	
	Equatorial latitudes southern hemisphere (EQS)	S0000 – S3000	
	Middle latitudes southern hemisphere (MSH)	S3000 – S6000	
High latitudes southern hemisphere (HSH)	S6000 – S9000		



## Geomagnetic Storms

- **Geomagnetic storms** disturb the ionosphere to affect HF communications and GNSS navigation in the high latitude (high latitudes northern hemisphere (HNH) and high latitudes southern hemisphere (HSH)) regions and sometimes include middle latitude (middle latitudes northern hemisphere (MNH) 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) HNH and HSH
  - b) HNH, HSH, MNH and MSH
  - c) EQN and EQS
  - d) MNH, MSH, EQN and EQS

*Note.1.— A single band (e.g. HNH) 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 (HNH)	N90 to N60
Middle latitudes northern hemisphere (MNH)	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



## 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)



## 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.
  - For 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.
  - For 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".



## 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.





## 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 EXP TO SUBSIDE IN THE FCST PERIOD. SEE WWW.SPACEWEATHERPROVIDER.WEB

### Next advisory

Year, month, day and time in UTC.

NXT ADVISORY: NO FURTHER ADVISORIES



FNXX01 YMMC 020100

SWX ADVISORY

DTG: 20190202/0100Z

SWXC: ACFJ

ADVISORY NR: 2019/10

SWX EFFECT: HF COM MOD

OBS SWX: 02/0100Z DAYLIGHT SIDE

FCST SWX + 6 HR: 02/0700Z DAYLIGHT SIDE

FCST SWX + 12 HR: 02/1300Z DAYLIGHT SIDE

FCST SWX + 18 HR: 02/1900Z NO SWX EXP

FCST SWX + 24 HR: 03/0100Z NO SWX EXP

RMK: LOW END OF BAND HF COM DEGRADED  
ON SUNLIT ROUTES. NEXT 12 HOURS  
MOST POSSIBLE, DECLINING THEREAFTER.

NXT ADVISORY: 20190202/0700Z=



## Examples

### Space weather advisory message (GNSS effects)

SWX ADVISORY  
DTG: 20161108/0100Z  
SWXC: DONLON\*  
ADVISORY NR: 2016/2  
NR RPLC: 2016/1  
SWX EFFECT: 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 AVBL IN THE AURORAL ZONE. THIS STORMING EXPTO SUBSIDE IN THE FCST PERIOD. SEE WWW. SPACEWEATHERPROVIDER.WEB  
NXT ADVISORY: NO FURTHER ADVISORIES



## Space weather advisory message (RADIATION effects)

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](http://WWW.SPACEWEATHERPROVIDER.WEB)  
NXT ADVISORY: NO FURTHER ADVISORIES



## Space weather advisory message (HF COM effects)

SWX ADVISORY

DTG: 20161108/0100Z

SWXC: DONLON\*

ADVISORY NR: 2016/1

SWX EFFECT: HF COM SEV

OBS SWX: 08/0100Z DAYLIGHT SIDE

FCST SWX +6 HR: 08/0700Z DAYLIGHT SIDE

FCST SWX +12 HR: 08/1300Z DAYLIGHT SIDE

FCST SWX +18 HR: 08/1900Z DAYLIGHT SIDE

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

RMK: PERIODIC HF COM ABSORPTION 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 WWW.

SPACEWEATHERPROVIDER.WEB

NXT ADVISORY: 20161108/0700Z



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# Dissemination of Space Weather Advisory



## Space Weather Advisory

- The space weather service and the obligations of a space weather Centre (SWXC) are provided in ICAO Annex 3 – *Meteorological Service for International Air Navigation*, Chapter 3, Section 3.8.
- Information relating to the space weather advisory (SWX Advisory), SWXA format : refer to Annex 3, Appendix 2:Section 6 and Table A2-3- Template for advisory message for space weather information..





## Communication network

- **Routing of SWX Advisories in text form** : will be similar to the current routing of **OPMET** messages, via the aeronautical fixed service (**AFS**), including the aeronautical fixed telecommunications network (**AFTN**) and the ATS Message Handling System (**AMHS**).
- **Routing of SWX Advisories in the IWXXM** : form will be made via the AMHS as an attachment utilizing the file transfer body part (FTBP) feature. **Exchange in IWXXM format has become standard practice as of 5 November 2020.**
- **Key players in the routing of SWX Advisories** : SWXCs, National OPMET Centres (**NOCs**), Regional OPMET Centres (**ROCs**) and the Inter-regional OPMET gateways (**IROGs**).
- The users will be able to obtain the SWX Advisory Information through their **NOC** or the secure internet services: the secure aviation data information service (**SADIS**); and the world area forecast system (**WAFS**) Internet File Service (**WIFS**).



## Message WMO headers

	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
SWXC SANSA	.....	....

01 = GNSS

02 = HF COM

03 = RADIATION

04 = SATCOM



## Messages routing – Originator Region

- **Space weather advisory centre (SWXC)**

- The SWXCs are the data originator. They will produce the SWX Advisories in text form and, from no later than 5 November 2020, in IWXXM form. They will send the SWX Advisories to their associated NOC.

- **National OPMET centre (NOC)**

- As necessary, the NOC associated with the SWXC (the Originating NOC) will add the bulletin (WMO) header and send it to all other SWXCs.
- The Originating NOC will also send the SWX Advisories to its associated ROC via the AFS and will distribute, or make available via agreed State briefing services, the SWX Advisories to users within its national area of responsibility.

- **Regional OPMET centre (ROC)**

- An originating ROC is responsible for the collection of the SWX Advisories from the originating NOC and for validation of the message format. The originating ROC will then disseminate the SWX Advisories, via AFS, to the IROGs within its region, to the RODBs within its region, to all other ROCs within its Region and to SADIS/WIFS.

- **Inter-regional OPMET gateway (IROG)**

- The IROGs in the originating regions are responsible for collection and dissemination of the SWX Advisories to their partner IROGs in other regions.



## Message routing – Receiving Region

- **Inter-regional OPMET gateway (IROG)**
  - The **receiving IROG** is responsible for the **collection of the SWX Advisories** and for the **dissemination to its associated ROCs and RODBs** in its region.
- **Regional OPMET Centre (ROC)**
  - A **ROC** will receive SWX Advisories from other regions via their IROG. **In turn, the ROC will distribute the SWX Advisories to all its associated NOCs.**
- **National OPMET Centre (NOC)**
  - **The NOC will distribute, or make available** via agreed State briefing services, **the SWX Advisories to users within its national area of responsibility.**
  - The distribution may be via a "push" service (e.g. AFTN), a "pull" service (e.g. an internet-based briefing service) or by other methods agreed to within the State.

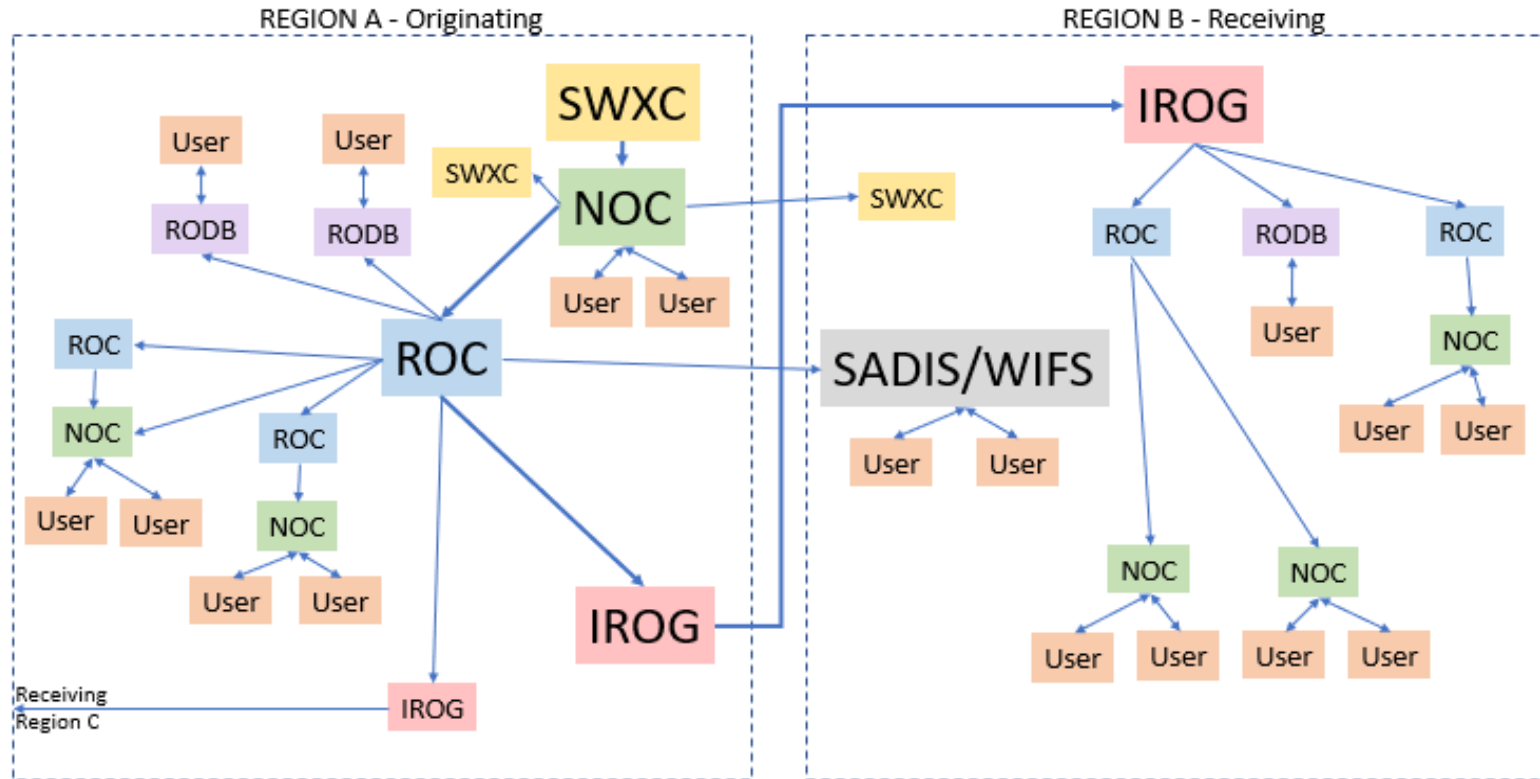


## Access to SWX information

- **User**
  - It is the **user's responsibility to ensure that they arrange for access to SWX Advisories through their NOC or through SADIS /WIFS.**
- **Regional OPMET Date Bank (RODB)**
  - **RODBs should provide the capability for users to interrogate information, such as the SWX Advisories, through the AFS.**
  - Replies to these requests are described in the **RODB Interface Control Documents.**
  - Reply reports of a request **will be aggregated into one** or more messages.



# Dissemination of SWX Advisory





## Space weather advisory information as required in the flight documentation

**Annex 3, Chap.9:9.1.3 refers** : Meteorological information supplied to operators and flight crew members shall be up to date and include the following information, as agreed between the meteorological authority and the operators concerned:

- a) forecasts of:
  - 1) upper wind and upper-air temperature;
  - 2) upper-air humidity;
  - .....
- b) b) METAR or SPECI (including trend forecasts as issued in accordance with regional air navigation agreement) for the aerodromes of departure and intended landing, and for take-off, en-route and destination alternate aerodromes;  
.....
- i) meteorological satellite images;
- j) ground-based weather radar information; and
- k) space weather advisory information relevant to the whole route.





## Conclusion

- The **SANSA** Centre has designated by APIRG to monitor and provide advisory information on space weather phenomena in the AFI Region
- The implementation of ICAO provisions related to Space Weather Information is lead by **APIRG IIM/SG Project 3 coordinated by South Africa**
- **Space weather service** would include advisories for space weather events affecting, or expected to affect, **Communications, GNSS-based navigation and Surveillance Systems** and pose a **Radiation risks to flight crew members and passengers** within the next 24 hours
- **Space weather risk mitigation system** is based on the **cooperation and coordination of all the stakeholders** (Aeronautical information services (**AIS**); Air Traffic flow management (**AFTM**) units; **Surveillance and communication** providers; **Aeronautical Meteorology Units; Operators; States, Civil aviation authorities (CAA); and SWXC**)



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