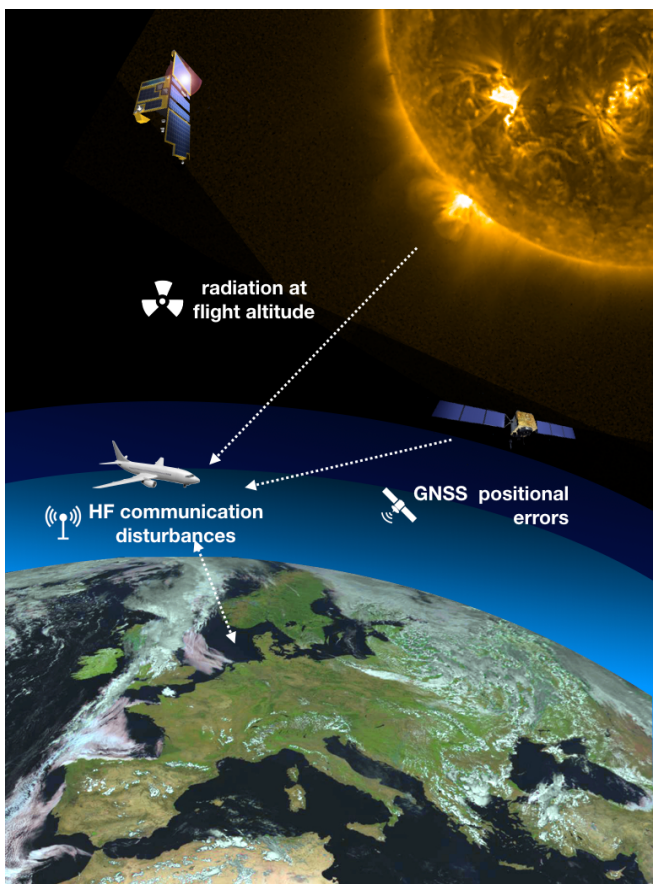
The ICAO Space Weather Information Service

Space Weather (SWX) and Aviation:

What is SWX? The Sun drives our planet's weather and climate patterns and is the main driver for space weather. SWX relates to the dynamic processes on the Sun which affect the interplanetary space and can impact various technological systems as well as human well-being on Earth.

Impacts on Aviation: SWX effects can impact GNSS, positioning and navigation, deteriorate and limit radio communications, or cause an increased radiation exposure at certain flight altitudes[3,4].

ICAO SWX Information Service: The goal is to advise aviation users when space weather events are expected to cause a moderate or severe impact related to the deterioration or loss of satellite navigation or HF communication (long-distance radio) or enhanced radiation dose at specific flight levels. Advisories are disseminated through ICAO's standard communication channels[5] and are required for completeness of flight documentation.



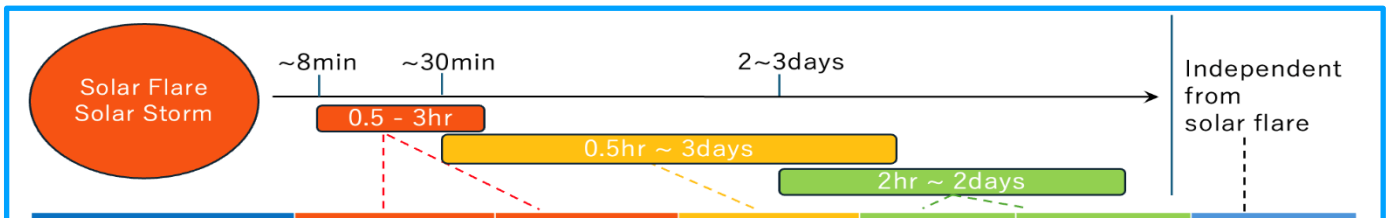
SWX Advisories in relation to other ICAO services:

- ★ Similar in structure to volcanic ash and tropical cyclone advisories.
- ★ Advisory triggers and relevant thresholds are defined in the Manual on Space Weather Information in Support of International Air Navigation, ICAO Doc101001; detailed service specification including advisory format is provided in Annex 32 and PANS-MET.
- ★ Spatial range of SWX Advisory can vary largely from isolated sections to large portions of the Earth.
- ★ Duration can range from tens of minutes to several days.
- ★ Impacted areas are one or more pre-defined latitude bands varying by 30 deg (eg. HNH, MNH, EQN) and a longitude range with 10 deg increments.

- ★ Note: SIGMETs and NOTAMs are NOT issued based on SWX Advisories

SWX Advisories in a nutshell:

- ★ Start: Resilient 24/7 staffed operations since November 2019.
- ★ Service: Near-real-time ICAO advisories issued by 4 global SWX centers supported by 1 regional center.
- ★ Impact: Cover domains of navigation (GNSS), radiation exposure (RAD) and radio communications (HF COM).
- ★ Standards: Impact-based advisory thresholds tailored to ICAO standards.
- ★ Updates: Within 6 hours from start of event
- ★ Severity levels: MOD/SEV



Phenomena		High Energetic Particle	Communication Blackout	Polar Cap Absorption	Auroral Absorption	Ionospheric Storm	Plasma Bubble
Critical Areas		High latitude region	Dayside region	Polar region	Auroral Oval	Mid-high latitude region	Low latitude region
Occurrence/dependency		• Once in several years • Depends on solar activity	• Several times a year • Depends on solar activity	• One to a few times a year • Depends on solar activity	• One to a few times a year • Strongly depends on solar activity	• Moderate: several times a year • Severe: several times a decade	• Solar activity dependence • Seasonal dependence
Impact	GNSS					Signal and Positioning degradation; Scintillation	Scintillation
	HF (radio) communication	HF waves absorption and signal degradation or loss. Especially at lower frequency range.				Decreasing maximum usable frequency	
	Radiation	Solar energetic particles					
Typical Impact Duration		• hours to days	• 30 mins ~ 1 hour	• hours to days	• several hours	• hours to days	• 1 hour ~ 1 day

Global Navigation Satellite System (GNSS):

Ionosphere's Role: The ionosphere, a top layer in our atmosphere ionized by sunlight, affects satellite navigation signals.

Signal Disruption: Solar storms can cause ionospheric disturbances, altering GNSS signal strength, velocity and phase.

Scintillation: This rapid change can prevent receivers from locking onto signals, making it hard to determine position.

VTEC: Increased vertical total electron content in the ionosphere during solar storms can cause positioning errors in satellite navigation.

Advisory Severity Levels: GNSS MOD; GNSS SEV

Increased radiation dose at flight levels (RAD):

Energetic Particles: During solar storm events, high-energy solar particles like protons can be rapidly accelerated and travel towards Earth.

Radiation Increase: Once energetic particles reach Earth, they can penetrate the atmosphere, especially close to the magnetic poles, creating a shower of particles, possibly reaching the ground.

Impact on Flights: This can affect crew and passengers by exposing them to increased levels of ionizing radiation, especially at high altitudes and polar routes.

Advisory Severity Levels: RADIATION MOD; RADIATION SEV

***Note**: MOD advisories will only be issued at and below FL460.

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0000063701
FNXX01 EFKL 271326
SWX ADVISORY
DTG:                20250227/1326Z
SWXC:               PECASUS
ADVISORY NR:        2025/116
SWX EFFECT:         GNSS MOD
OBS SWX:            27/1313Z HNH W090 - W060
FCST SWX +6 HR:     27/2000Z EQN EQS W030 - E000
FCST SWX +12 HR:    28/0200Z EQN EQS W075 - W030
FCST SWX +18 HR:    28/0800Z NOT AVBL
FCST SWX +24 HR:    28/1400Z EQN E105 - E135
RMK:                SPACE WEATHER EVENT (IONOSPHERIC
SCINTILLATION) IN PROGRESS. IMPACT ON GNSS PERFORMANCE
POSSIBLY LEADING TO LOSS OF GNSS SIGNALS AND/OR DEGRADATION
 OF TIMING AND POSITIONING PERFORMANCE.
NXT ADVISORY:       WILL BE ISSUED BY 20250227/1913Z=
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Advisory headers

Issuing center

Type and severity level

Impacted area

Issue advisory update within 6h of OBS time

```
0000050101
FNXX01 EFKL 251227
SWX ADVISORY
STATUS:             TEST
DTG:                20251227/1155Z
SWXC:               DONLON
ADVISORY NR:        2025/5
NR RPLC:            2025/4
SWX EFFECT:         RAD MOD
OBS SWX:            27/1145Z HNH HSH MNH MSH W180 - E180
ABV FL430
FCST SWX +6 HR:     27/1800Z HNH HSH MNH MSH W180 - E180
FCST SWX +12 HR:    28/0000Z NO SWX EXP
FCST SWX +18 HR:    28/0600Z NO SWX EXP
FCST SWX +24 HR:    28/1200Z NO SWX EXP
RMK: SPACE WEATHER EVENT IN PROGRESS CAUSING
INCREASED RADIATION LEVELS AT FLIGHT ALTITUDE(S).
NXT ADVISORY:       WILL BE ISSUED BY 20251227/1745Z=
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used only for TEST/EXERCISE

For advisory follow-up

Impacted flight levels

HF communication (HF COM) :

HF Radio Waves: These waves (3-30 MHz) are used for long-distance communication, especially important for polar and transatlantic flights.

Ionosphere's Role: The ionosphere reflects HF radio waves, enabling communication beyond the horizon by bouncing signals between the Earth and the ionosphere.

Impact of Solar Storms: Events like solar flares and coronal mass ejections add extra energy to the ionosphere, highly disturbing it.

Communication Disruption: This extra energy can cause unexpected absorption or reflection of HF radio waves, leading to communication failures.

Affected Areas: Disruptions can occur near the poles, on the sunlit side of the Earth or even affect the entire globe, depending on the type and severity of the solar storm.

MUF Reduction: Ionospheric changes after geomagnetic storms can significantly lower the maximum usable frequency (MUF) for HF communication, affecting any location on Earth.

Advisory Severity Levels: HF COM MOD; HF COM SEV

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0000059801
FNXX02 EFKL 250647
SWX ADVISORY
DTG:              20250225/0647Z  → Issue date-time
SWXC:             PECASUS
ADVISORY NR:      2025/47
NR RPLC:          2025/46
SWX EFFECT:       HF COM MOD      → Event start date-time
OBS SWX:          25/0628Z HNH HSH W180 - E180
FCST SWX +6 HR:   25/1300Z HNH HSH W180 - E180
FCST SWX +12 HR:  25/1900Z NO SWX EXP
FCST SWX +18 HR:  26/0100Z NO SWX EXP
FCST SWX +24 HR:  26/0700Z NO SWX EXP
RMK:              SPACE WEATHER EVENT (HF COM POLAR CAP
ABSORPTION) IN PROGRESS. IMPACT ON LOWER HF COM FREQUENCY
BANDS EXPECTED AT HIGH LATITUDES.
NXT ADVISORY:     WILL BE ISSUED BY 20250225/1228Z=
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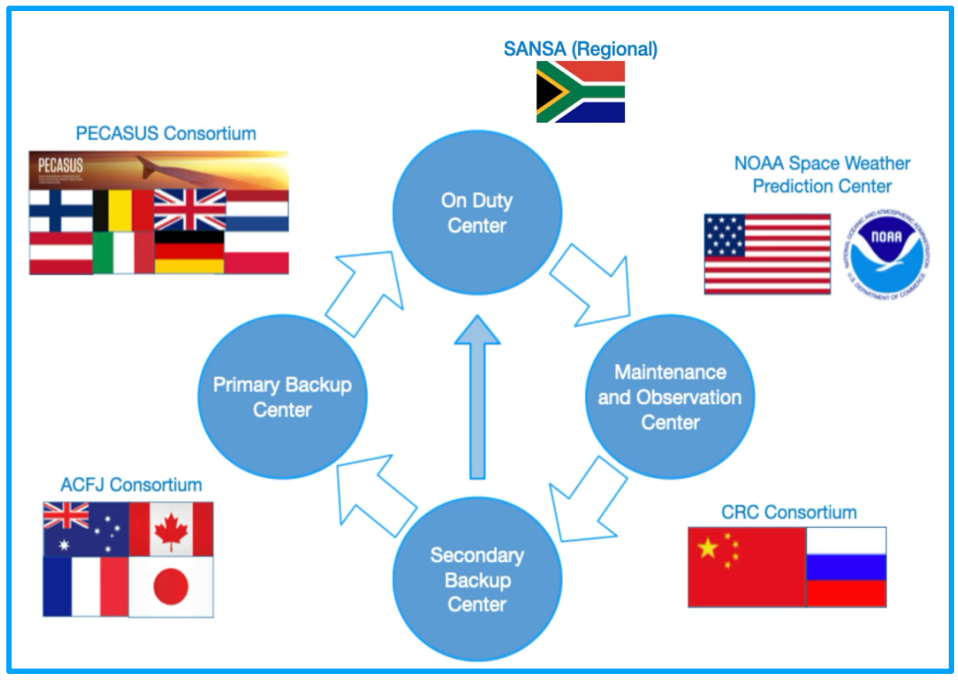
Complimentary information, including advisory trigger and expected impacts

Dissemination of SWX Advisories via AFS/ATN*

- ★ Advisories are disseminated in TAC and IWXXM formats with different WMO headers[5].
- ★ SWX advisories for different domains (GNSS, HF COM, RAD) have different WMO headers.
- ★ Every global SWX center has a WMO header.

01 = GNSS
02 = HF COM
03 = RADIATION



Space Weather Information Service Provision Centers:

Four global centers (PECASUS, ACFJ, SWPC and CRC) provide ICAO SWX services, switching responsibility roles in a 2-weekly rotational principle. The global centers are supported by a regional center (SANSA) which does not participate in the rotational duty cycle and distribution of advisories, but continuously supports the "On Duty" center with additional datasets and models.

Upcoming changes to the SWX Advisories:

- ★ Custom-area based on polygons with maximum 6 corners (7 points) using geographic coordinates and resolution of 5° in latitude and longitude (effective Nov 2025).
- ★ Severity level moved from "SWX EFFECT" to the "OBS SWX" advisory field (i.e. linked to the polygon area specification).
- ★ Possibility to close multiple advisories simultaneously.
- ★ DAYSIDE will replace DAYLIGHT SIDE referring to the Sun-lit portion of the planet. DAYSIDE and NIGHTSIDE keywords to be used stand alone or in combination with latitudinal bands to indicate either the union of Sun-lit/day or the cross-section of dark/night part of the world with other indicated areas.

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0000050101
FNXX01 EFKL 251127
SWX ADVISORY
DTG:              20251127/1210Z
SWXC:             DONLON
ADVISORY NR:      2025/313
NR RPLC:          2025/311 2025/312
SWX EFFECT:       GNSS
OBS SWX:          27/1200Z SEV N80E000-N80E090-N60E090-N60E000-N80E000
MOD S60E000-S60E090-S80E090-S80E000-S60E000
FCST SWX +6 HR:   27/1800Z MOD N80E000-N80E090-N60E090-N60E000-N80E000
SEV S60E000-S60E090-S80E090-S80E000-S60E000
FCST SWX +12 HR:  28/0000Z NO SWX EXP
FCST SWX +18 HR:  28/0600Z NO SWX EXP
FCST SWX +24 HR:  28/1200Z NO SWX EXP
RMK: THIS IS A SAMPLE GNSS SPACE WEATHER ADVISORY BASED ON POLYGONS.
     PLEASE DISREGARD.
NXT ADVISORY:     WILL BE ISSUED BY 20251127/1800Z=
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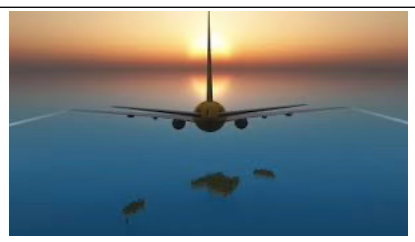
SEV and FL information linked to polygon areas

Have a safe flight!



Reference documents:

1. https://store.icao.int/en/manual-on-space-weather-information-in-support-of-international-air-navigation-doc-10100
2. https://store.icao.int/en/annex-3-meteorological-service-for-international-air-navigation-1
3. https://www.faa.gov/sites/faa.gov/files/other_visit/aviation_industry/airline_operators/airline_safety/InFO20007.pdf
4. https://ad.easa.europa.eu/blob/EASA_SIB_2012_09_R1.pdf/SIB_2012-09R1_1
5. https://www2023.icao.int/airnavigation/METP/Panel%20Documents/SWXA_Additional%20Information.pdf

*AFS stands for Aeronatical Fixed Service and ATN refers to Aeronautical Telecommunication Network