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Subject: International Civil Aviation Organization (ICAO) Space Weather - Centers and ICAO Space Weather Advisories.

Purpose: This InFO serves to provide information on the new provision of ICAO Space Weather Centers and Space Weather Advisories.

Background: Solar activity and monitoring has matured. Accordingly, the ICAO Meteorology Panel recommends using a global monitoring program. This program consists of the following three global space weather service providers:

- The United States, which will be managed by the National Oceanic and Atmospheric Administration's (NOAA) Space Weather Prediction Center (SWPC)
- The consortium, comprising of space weather agencies from Australia, Canada, France and Japan (ACFJ)
- The Pan-European Consortium for Aviation Space Weather User Services (PECASUS) consortium, comprising of space weather agencies from Finland (Lead), Belgium, United Kingdom, Poland, Germany, Netherlands, Italy, Austria, Cyprus and South Africa

On November 7, 2019, SWPC, ACFJ, and PECASUS began serving, on a rotating basis, as the three global space weather centers sharing responsibility for issuing space weather advisories that are consistent with international standards under ICAO Annex 3 - *Meteorological Service for International Air Navigation.* ICAO's Annex 3, when read with ICAO Doc 10100 – *Manual on Space Weather Information in Support of International Air Navigation*, provides the technical parameters and application consistent with space weather advisories, when: impacts to high frequency communications (HF COM); communications via satellite (SATCOM); satellite (GNSS) based navigation and surveillance systems; or heightened radiation occurs above flight level (FL) 250.

Discussion: A space weather advisory is issued whenever space weather conditions exceed pre-defined ICAO thresholds for both moderate impacts (MOD) and severe impacts (SEV) as given in the table below. The space weather advisory is neither a significant meteorological (SIGMET) product nor a product that is equivalent to a SIGMET. The space weather advisory is not a replacement for SWPC's other products or the NOAA Space Weather Scales, which will continue to be provided by the SWPC.

Moderate impact radiation advisories will only be issued when the MOD threshold is reached between FL250 and FL460. SEV radiation advisories will be issued when the SEV threshold is reached at any FL above FL250. For context, the background effective dose rate at FL370 at very high latitudes is approximately 8 micro-Sieverts/hour. These rates decrease progressively toward the equatorial regions to values approximately one quarter of what is observed at very high latitudes. Severe impact radiation is a rare event, as only a few short-lived events occur during an 11-year solar cycle.

<table>
<tr><th rowspan="2">Effect</th><th rowspan="2">Sub-effect</th><th rowspan="2">Parameter used</th><th colspan="2">Thresholds</th><th colspan="2">Impact within advisory area</th></tr>
<tr><th>MOD</th><th>SEV</th><th>MOD</th><th>SEV</th></tr>
<tr><td>GNSS</td><td>Amplitude Scintillation</td><td>S4 (dimensionless)</td><td>0.5</td><td>0.8</td><td rowspan="3">Possible degraded service</td><td rowspan="3">Possible unreliable service</td></tr>
<tr><td>GNSS</td><td>Phase Scintillation</td><td>Sigma-phi (radians)</td><td>0.4</td><td>0.7</td></tr>
<tr><td>GNSS</td><td>Vertical Total Electron Content (TEC)</td><td>TEC units</td><td>125</td><td>175</td></tr>
<tr><td>RADIATION</td><td></td><td>Effective dose rate (micro-Sieverts/hour)</td><td>30</td><td>80</td><td colspan="2">Possible increased dose rates above normal levels.</td></tr>
<tr><td>HF COM</td><td>Auroral Absorption (AA)</td><td>Kp index</td><td>8</td><td>9</td><td rowspan="4">Possible degraded service</td><td rowspan="4">Possible unreliable service</td></tr>
<tr><td>HF COM</td><td>Polar Cap Absorption (PCA)</td><td>dB from 30MHz riometer data</td><td>2</td><td>5</td></tr>
<tr><td>HF COM</td><td>Shortwave Fadeout (SWF)</td><td>Solar X-rays (0.0-0.8 nm) ($W\text{-}m^{-2}$)</td><td>$1x10^{-4}$ (X1)</td><td>$1x10^{-3}$ (X10)</td></tr>
<tr><td>HF COM</td><td>Post-Storm Depression</td><td>Maximum usable frequency (MUF)</td><td>30%</td><td>50%</td></tr>
<tr><td>SATCOM</td><td colspan="4">No threshold has been set for this effect</td><td>Possible degraded service</td><td>Possible unreliable service</td></tr>
</table>

The space weather advisory provides information regarding an observed or expected occurrence and location of a space weather effect and the forecast of the effect at 6-, 12-, 18- and 24-hour intervals. The advisory depicts the affected region in one of three ways:

- Six pre-defined latitude bands of width 30° shown in the table below (multiple bands may be given in one advisory), followed by a longitude range in 15° increments*; or
- the term DAYLIGHT SIDE, meaning the extent of the planet that is in daylight; or
- a polygon using latitude and longitude coordinates

*Note: *E18000-W18000 (or E180-W180) is used when the entire band is affected.*

Latitude bands used in space weather advisories

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

The horizontal, vertical and temporal resolutions of the advisory are very coarse. The use of 30-degree latitude bands, 15-degree longitude increments, 3,000-foot vertical increments (for radiation), and 6-hour time intervals will, at times, result in over forecasting the affected airspace. In addition, while an entire latitude band might be forecast to have MOD or SEV space weather, the effect, at times, does not cover the entire width of the band or might be intermittent or temporary. Users may refer to the remarks section of the advisory for additional information. Users can also go to the center's website where a graphical depiction of the space weather event may be provided along with additional information.

Format of the space weather advisory:

Format	Explanation	Examples
Communication header	Product's coded identification for the issuing centers. KWNP is SWPC, LFPW and YMMC are ACFJ, and EFKL is PECASUS.	FNXX01 KWNP FNXX01 LFPW FNXX01 YMMC FNXX01 EFKL
SWX ADVISORY	Space weather (SWX) advisory	SWX ADVISORY
STATUS:	Status indicator (optional) for Test or Exercise	TEST EXER
DTG:	Date and time of origin, in YYYYMMDD/HHMMZ	20190418/0100Z
SWXC:	Name of the Space Weather Advisory Center (SWXC)	ACFJ PECASUS SWPC
ADVISORY NR:	Advisory number (NR)	2019/9
NR RPLC:	Advisory number being replaced by this advisory (optional)	2019/8
SWX EFFECT:	Space weather effect	HF COM MOD

Format	Explanation	Examples
		HF COM SEV SATCOM MOD SATCOM SEV GNSS MOD GNSS SEV RADIATION MOD RADIATION SEV
OBS (or FCST) SWX:	Observed (OBS) or expected (FCST) space weather effect date/time, location and altitudes (altitudes are only used in the radiation advisory).	18/0100Z EQN W18000-W12000 18/0100Z HNH HSH E180-W180 ABV FL370 18/0100Z DAYLIGHT SIDE 18/0100Z NO SWX EXP
FCST SWX +6 HR:	6-hour forecast. Date/time, location and altitudes.	Same as above
FCST SWX +12 HR:	12-hour forecast. Date/time, location and altitudes.	Same as above
FCST SWX +18 HR:	18-hour forecast. Date/time, location and altitudes.	Same as above
FCST SWX +24 HR:	24-hour forecast. Date/time, location and altitudes.	Same as above
RMK:	Remarks (RMK)	Additional information
NXT ADVISORY:	Date/time when the next (NXT) scheduled advisory will be issued	2010418/0700Z

Example. Space weather advisory – GNSS

Note: GNSS is the acronym for Global Navigation Satellite System, which is the term for all the world's navigation satellites, which includes the US's Global Position Satellites (GPS).

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FNXX01 KWNP 020100
SWX ADVISORY
DTG:              20190502/0100Z
SWXC:             SWPC
ADVISORY NR:      2019/59
NR RPLC:          2019/58
SWX EFFECT:       GNSS MOD
OBS SWX:          02/0100Z HNH HSH E18000-W18000
FCST SWX + 6 HR:  02/0700Z HNH HSH E18000-W18000
FCST SWX + 12 HR: 02/1300Z HNH HSH E18000-W18000
FCST SWX + 18 HR: 02/1900Z NO SWX EXP
FCST SWX + 24 HR: 03/0100Z NO SWX EXP
RMK:              IONOSPHERIC STORM CONTINUES TO CAUSE LOSS-OF-LOCK
                  OF GNSS IN AURORA ZONE. THIS ACTIVITY IS
                  EXPECTED TO SUBSIDE IN THE FORECAST PERIOD
NXT ADVISORY:     20190502/0700Z=
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Example. Space weather advisory – RADIATION

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FNXX01 EFKL 190300
SWX ADVISORY
DTG:              20190219/0300Z
SWXC:             PECASUS
ADVISORY NR:      2019/20
SWX EFFECT:       RADIATION MOD
OBS SWX:          19/0300Z HNH HSH E18000-W18000 ABV FL370
FCST SWX + 6 HR:  19/0900Z NO SWX EXP
FCST SWX + 12 HR: 19/1500Z NO SWX EXP
FCST SWX + 18 HR: 19/2100Z NO SWX EXP
FCST SWX + 24 HR: 20/0300Z NO SWX EXP
RMK:              RADIATION AT AIRCRAFT ALTITUDES ELEVATED
                  BY SMALL ENHANCEMENT JUST ABOVE PRESCRIBED
                  THRESHHOLD. DURATION TO BE SHORT-LIVED
NXT ADVISORY:     NO FURTHER ADVISORIES=
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Example. Space weather advisory – HF COM

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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=
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Changes to the space weather advisory content and format are possible.

Additional information is available in ICAO Annex 3 – *Meteorological Service for International Air Navigation* and ICAO Doc 10100 – *Manual on Space Weather Information in Support of International Air Navigation*.

Recommended Action: Directors of Safety and Directors of Operations should be aware of the information in this InFO regarding access to the SWPC advisories. Consistent with existing regulations, certificate holders should keep manuals up-to-date concerning actions to take upon reviewing SWPC advisories.

Contact: Questions or comments regarding this InFO should be directed to the Air Transportation Division's Air Carrier Operations Branch, at 202-267-8166.