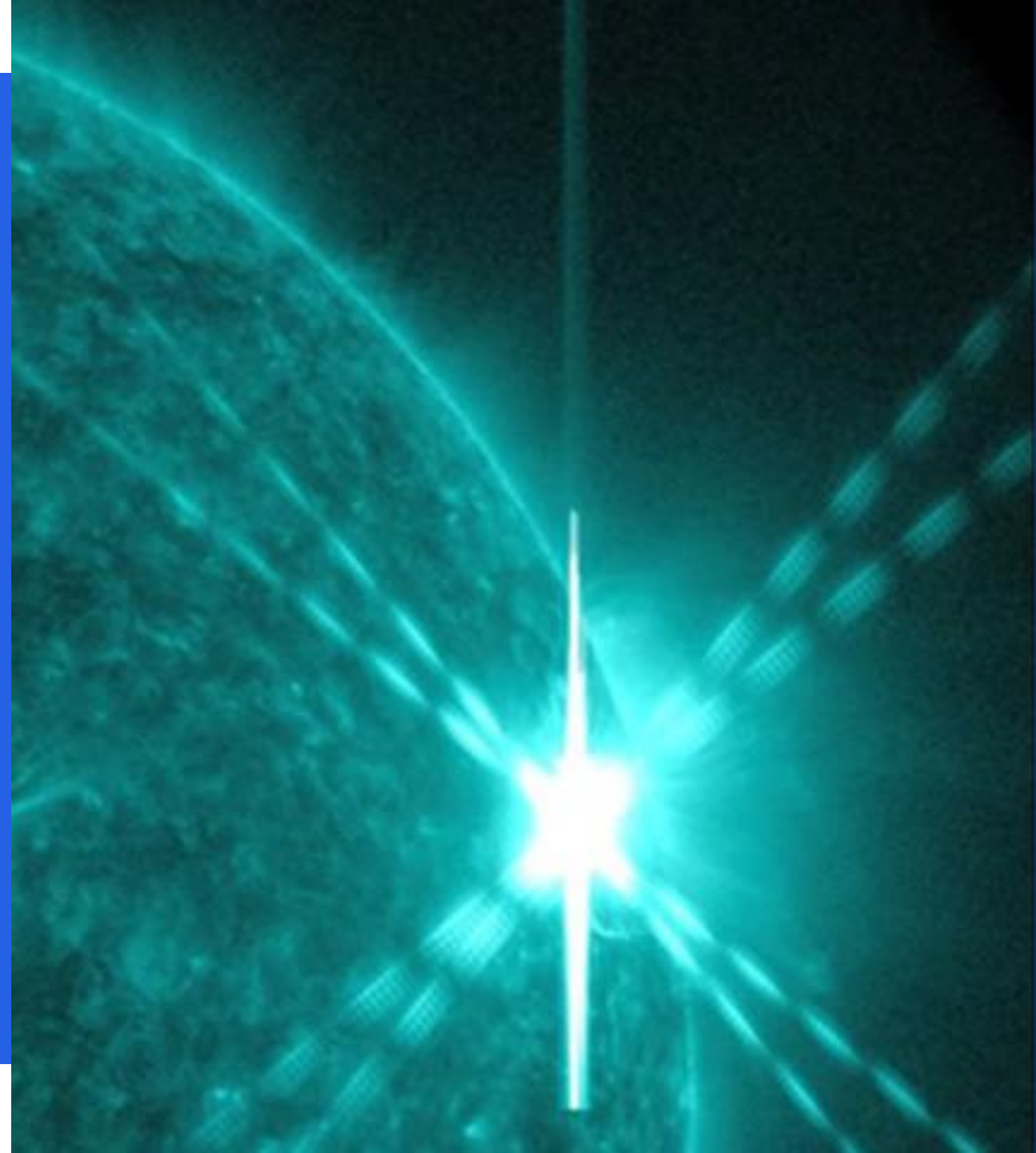


Space Weather Exercise – educational focus and scenario

Jarrad Denman, Bureau of Meteorology



Approach to the Space Weather Exercise

Space Weather (SWX) Exercise

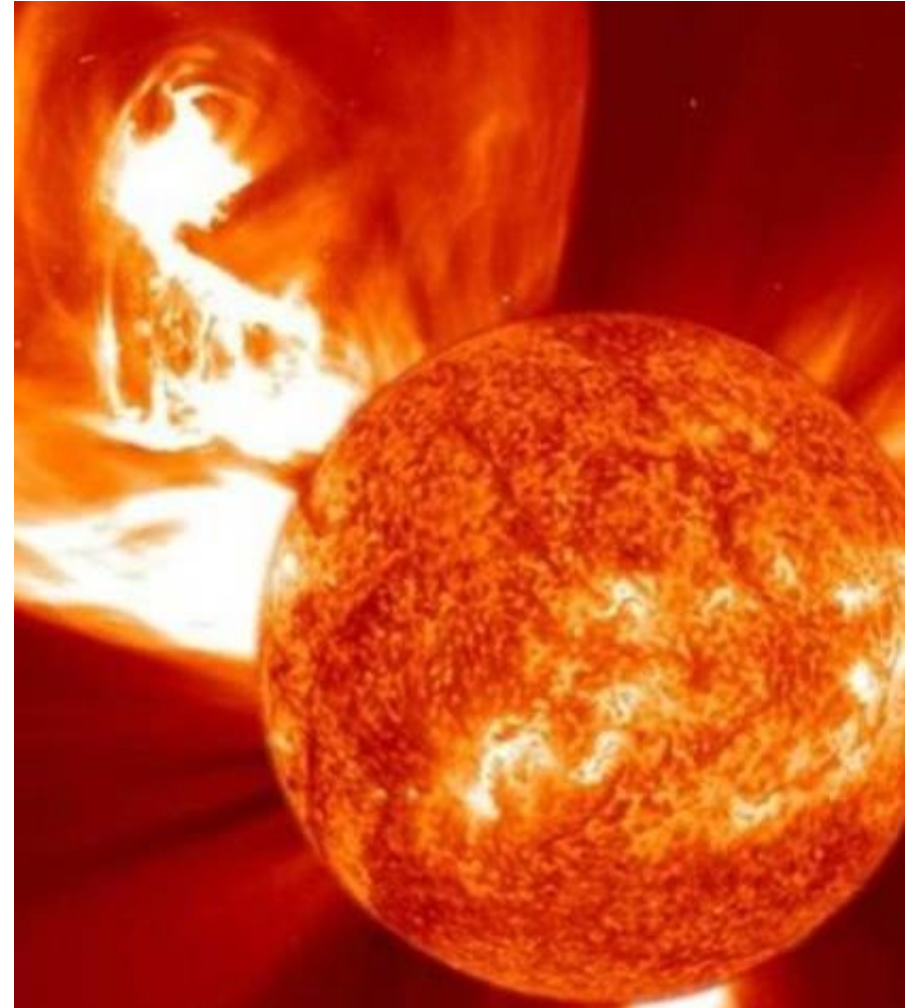
Held over two days (Wednesday 18th October and Wednesday 26th October)

Focus:

- First day: providing an overview of space weather and the ICAO service, ANSP and airline examples of procedures, general discussion and 'homework' to follow up on the exercise.
- Second day: a scenario exercise for HF communication advisories and how operators would respond to this information. 'Easier' scenario for first exercise.

Attendees – kept it small for first exercise:

- Airlines, Met Services Providers, ANSPs, Regulators from AU, NZ & FJ
- ICAO Office



First day of Space Weather Exercise

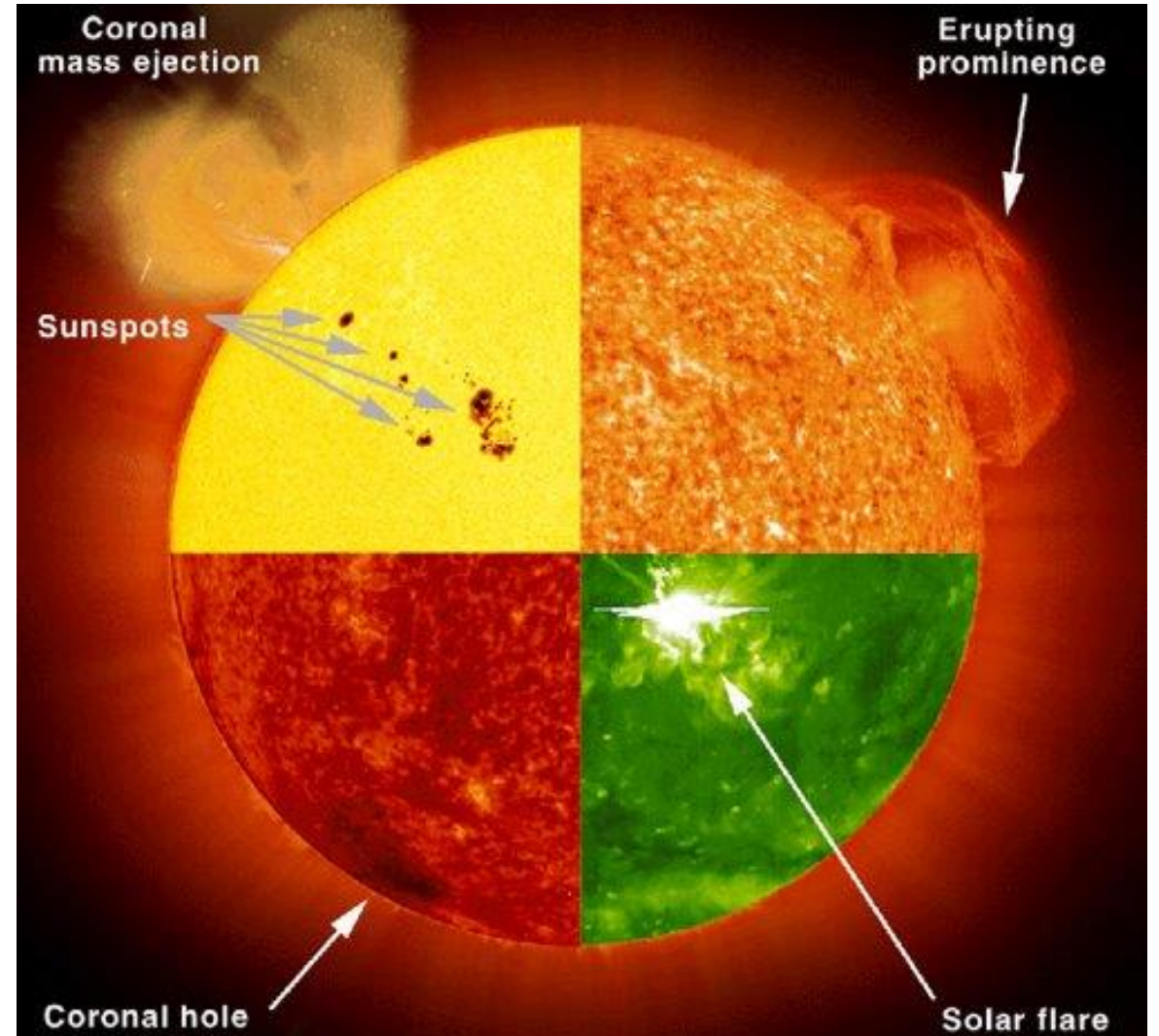
Space Weather Sources

Solar wind - continuous stream of charged particles emitted in all directions

Solar flares – sudden burst of electromagnetic radiation, particularly at X-ray wavelengths. Typically originate from magnetically complex regions on the surface where sunspots are found

Coronal Mass Ejections - large clouds of plasma and magnetic field which erupt in the Sun's outer atmosphere. These can be Earth-directed, causing geomagnetic and ionospheric storms

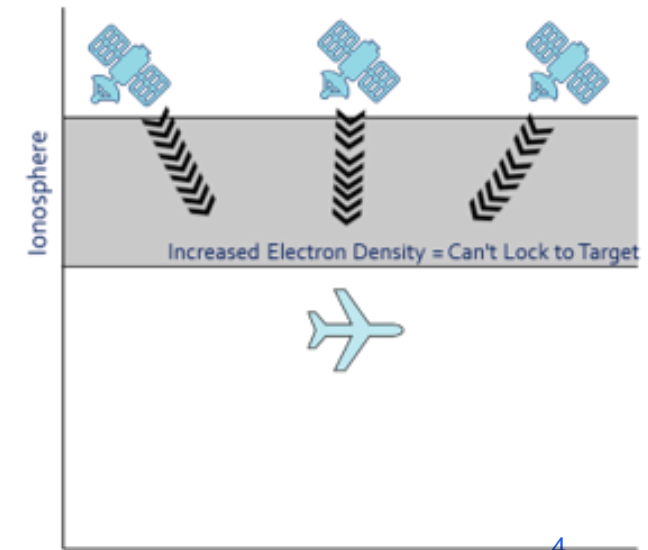
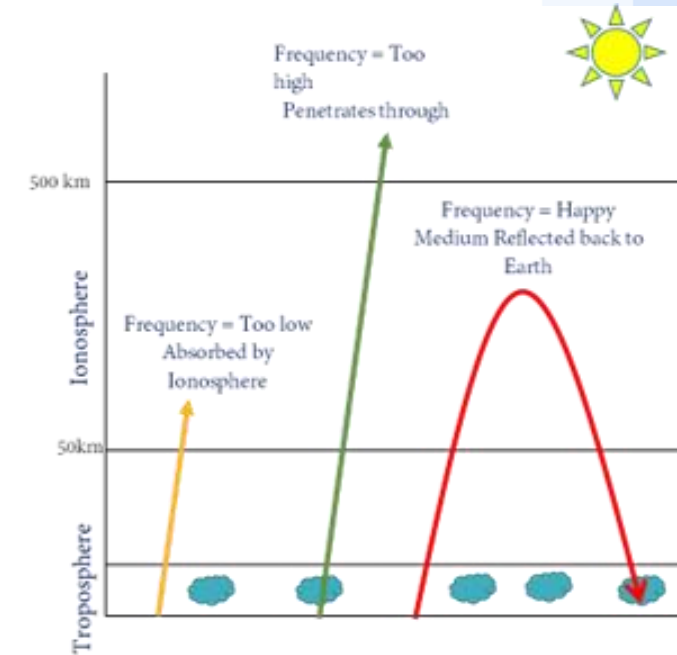
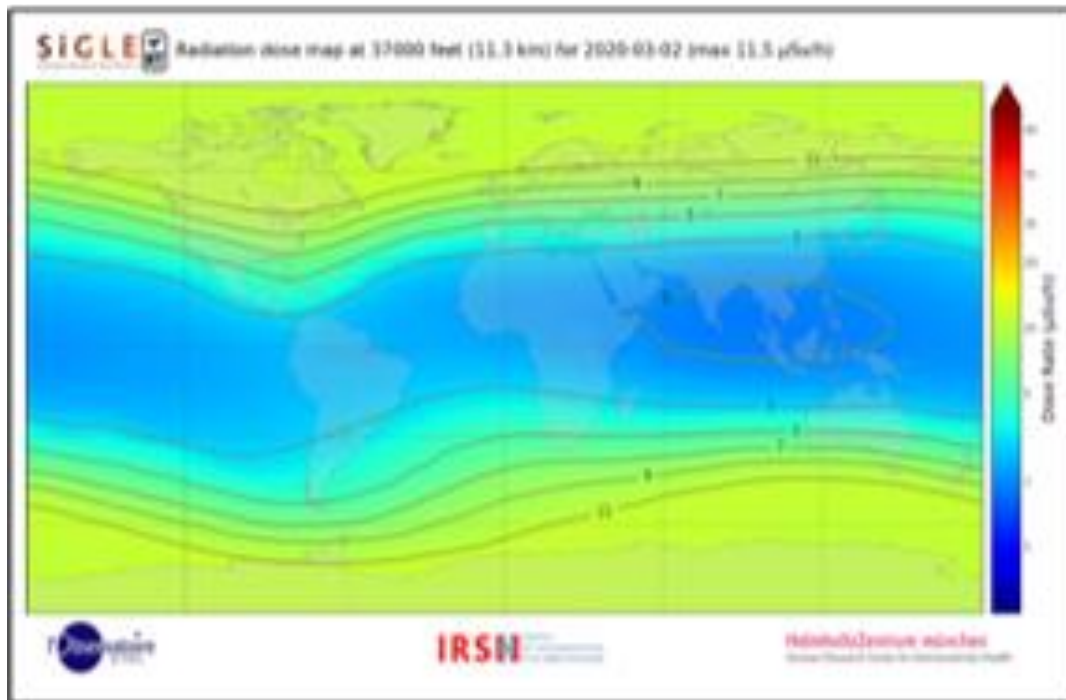
Particle radiation events - bursts of high-energy protons accelerated in Sun's outer atmosphere. Can arrive in 15 minutes – hours if Earth-directed



First day of Space Weather Exercise

SWX Impacts on Aviation

- High Frequency (HF) Communication
- Global Navigation Satellite Systems (GNSS)
- Radiation
- Satellite Communication (SATCOM)



First day of Space Weather Exercise

ICAO Service

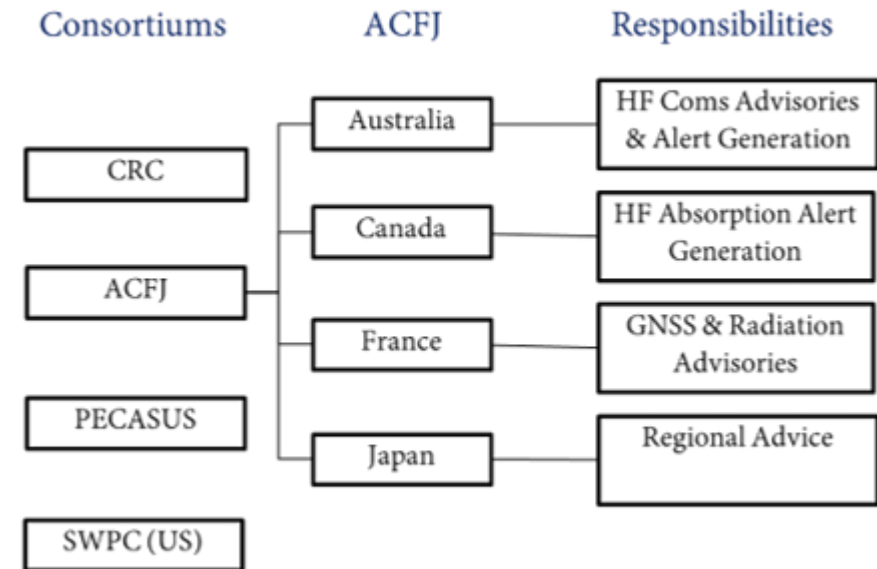
Space Weather Advisories (SWXA) have been an ICAO standard since November 2020.

Global ICAO service provided by four consortiums acting on a two week rotating roster.

One consortium will act as the On Duty Centre (ODC), one will act as the Primary Backup Centre (PBC), one as the Secondary Backup Centre (SBC) and the final as the Maintenance and Observation Centre (MOC).

Handovers will occur fortnightly on Tuesdays at 0745UTC.

Briefings prepared by ACFJ will be run by the Bureau of Meteorology Space Weather Scientist



First day of Space Weather Exercise

ICAO Service

No SIGMET for SWX

Advisories will be issued for two intensity thresholds: Moderate (MOD) and Severe (SEV)

Alerting thresholds are defined in ICAO Manual on Space Weather Information in Support of International Air Navigation (Doc 10100)

Four broad space impact areas for aviation:

- HF Communication (HF COM)
- GNSS-base navigation and surveillance (GNSS)
- Radiation impacts on avionics and health (RADIATION)
- Satellite communications (SATCOM)**

Effect	Sub-effect	Threshold Parameter	MOD	SEV
GNSS	Amplitude Scintillation	S4 (dimensionless)	0.5	0.8
GNSS	Phase Scintillation	Sigma-phi (radians)	0.4	0.7
GNSS	Vertical Total Electron Content (TEC)	TEC units	125	175
RADIATION		Effective dose rate (micro-Sieverts/hour)*	30	80
HF COM	Auroral Absorption (AA)	Kp index	8	9
HF COM	Polar Cap Absorption (PCA)	dB from 30MHz riometer data	2	5
HF COM	Shortwave Fadeout (SWF)	Solar X-rays (0.1-0.8 nm) (W-m ⁻²)	1x10 ⁻⁴ (X1)	1x10 ⁻³ (X10)
HF COM	Post-Storm Depression	Maximum Usable Frequency (MUF)**	30%	50%
SATCOM	No threshold has been set for this effect			

*MOD advisories will only be issued when the MOD threshold is reached between FL250 and FL460. SEV advisories will be issued when the SEV threshold is reached between FL250 and FL600.

**As compared to a 30-day running median.

Phenomena	WMO Header TAC	WMO Header IWXXM
GNSS	FNXX01	LNXX01
HF COM	FNXX02	LNXX02
Radiation	FNXX03	LNXX03
SATCOM**	FNXX04	LNXX04



First day of Space Weather Exercise

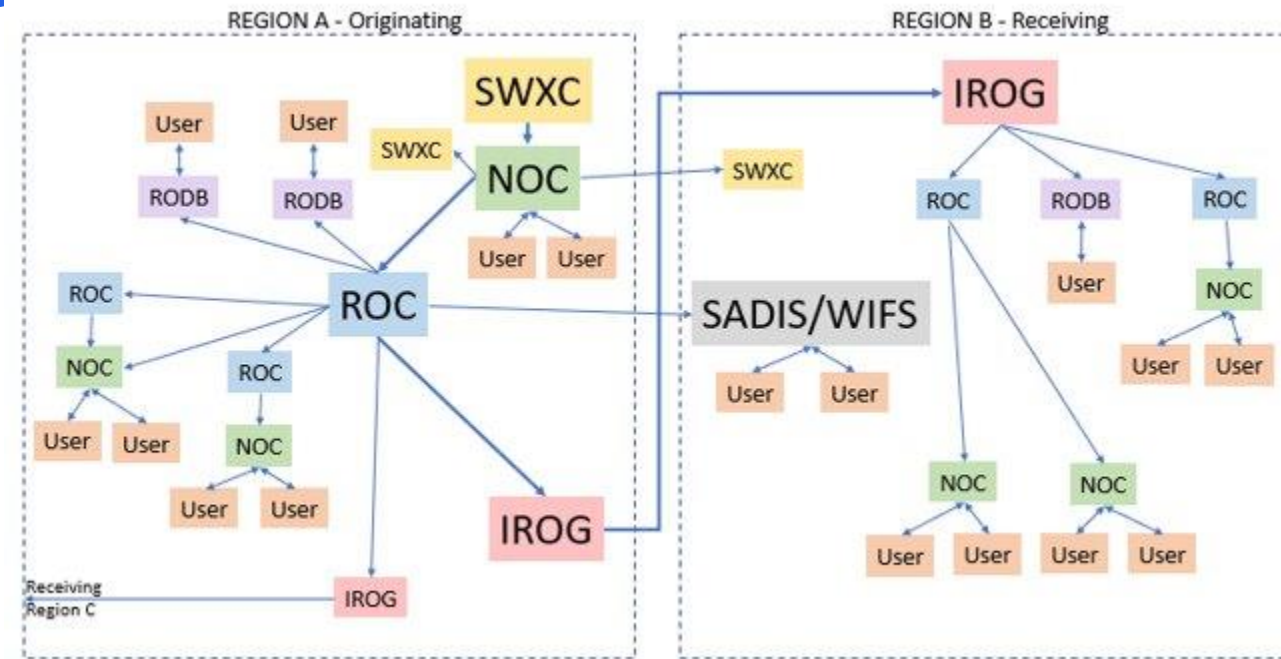
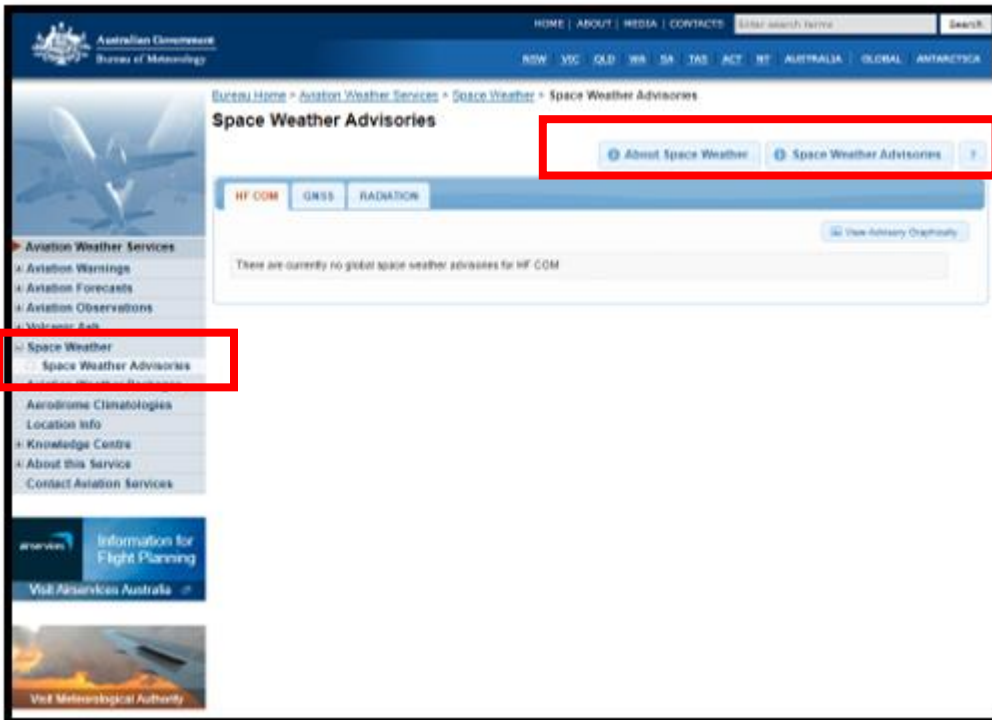
Space Weather Dissemination

SWXA are disseminated via AA on AFS

Also on the BoM webpage

(<http://www.bom.gov.au/aviation/space-weather-advisories/>) and in NZ via MetFlight/PreFlight/IFIS

SWX Brochures on the BoM webpage



Refer to ICAO Regional OPMET Exchange (ROBEX Handbook)

https://www.icao.int/APAC/Documents/edocs/2022-03_ROBEX-HB_14th-Ed.pdf



First day of Space Weather Exercise

Space Weather Dissemination

Day 1 concluded with

- 1) reviewing a real GNSS advisory that was issued during the session (left)
- 2) Bureau issuing a test advisory (right)

FNXX01 LFPW 190039

SWX ADVISORY

DTG: 20221019/0021Z

SWXC: ACFJ

ADVISORY NR: 2022/25

SWX EFFECT: GNSS MOD

OBS SWX: 18/2345Z EQN EQS W105 - W000

FCST SWX +6 HR: 19/0600Z NOT AVBL

FCST SWX +12 HR: 19/1200Z NOT AVBL

FCST SWX +18 HR: 19/1800Z NOT AVBL

FCST SWX +24 HR: 20/0000Z NOT AVBL

RMK: SWX EVENT (SCINTILLATION) INPR

POSSIBLY IMPACTING GNSS PER.

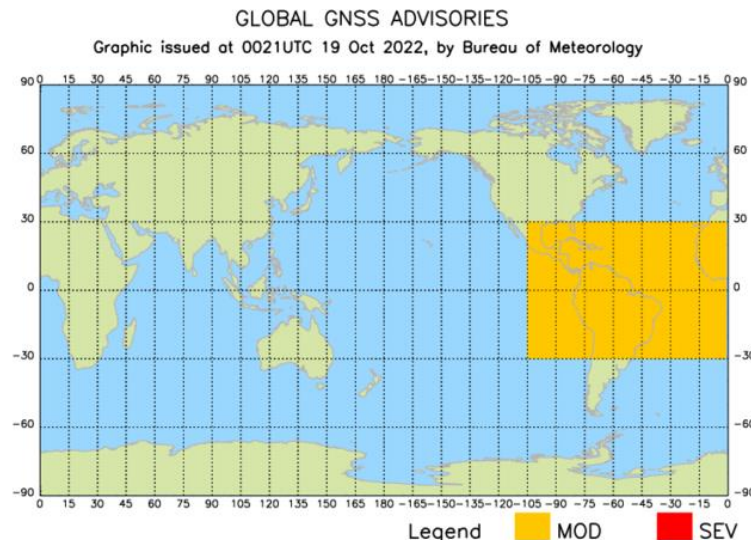
COULD LEAD TO DEGRADATION OF TIMING

AND POSITIONING PER. INTST

GENERALLY STRONGER ON THE NIGHTSIDE.

NXT ADVISORY: WILL BE ISSUED BY

20221019/0621Z=



FNXX02 YMMC 190100

SWX ADVISORY

STATUS: EXER

DTG: 20221019/0100Z

SWXC: ACFJ

ADVISORY NR: 2022/85

SWX EFFECT: HF COM MOD

OBS SWX: 19/0050Z NO SWX EXP

FCST SWX +6 HR: 19/0700Z NO SWX EXP

FCST SWX +12 HR: 19/1300Z NO SWX EXP

FCST SWX +18 HR: 19/1900Z NO SWX EXP

FCST SWX +24 HR: 20/0100Z NO SWX EXP

RMK: EXERCISE EXERCISE TESTING DISSEMINATION.

PLEASE DISREGARD.

NEXT ADVISORY: NO FURTHER ADVISORIES



Second day of Space Weather Exercise

Space Weather Dissemination

Reviewed and discussed results about reception of both real and test advisories by each organisation

Discussed each organisation's procedures for space weather affects on operations

Mitigation processes to solve any issues and requirements from Air Traffic Controllers during these events

Note: It is unclear whether there is a requirement for ANSPs to broadcast SWXA



Second day of Space Weather Exercise

Space Weather Scenario

The event simulated a strong solar flare which would affect HF COM starting at MOD and soon after reaching SEV levels.

FNXX02 YMMC 252200

SWX ADVISORY

DTG: 20221025/2200Z

SWXC: ACFJ

ADVISORY NR: 2022/9

SWX EFFECT: **HF COM MOD**

OBS SWX: 25/2155Z DAYLIGHT SIDE

FCST SWX + 6 HR: 26/0400Z NOT AVBL

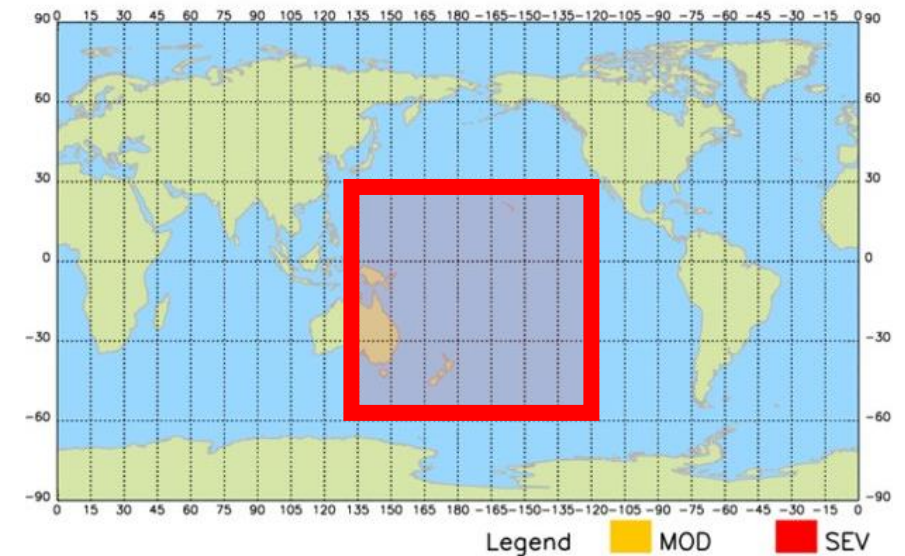
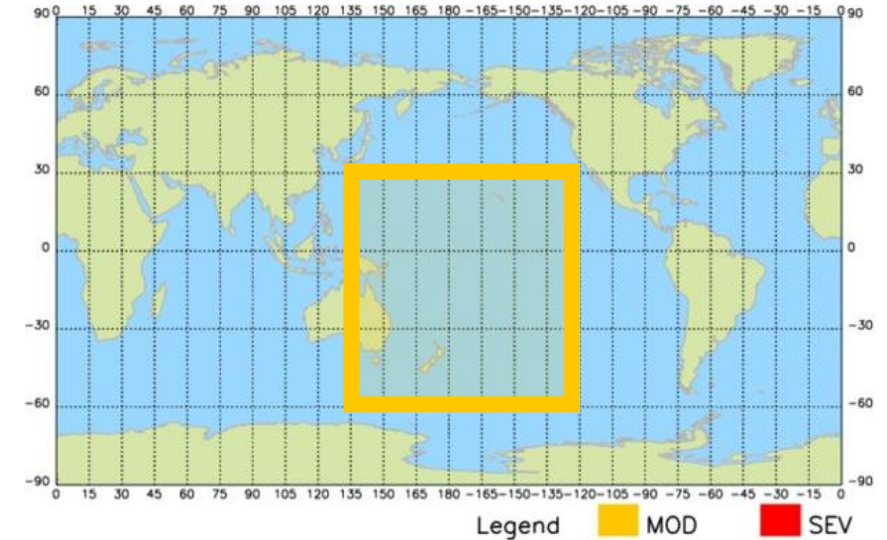
FCST SWX + 12 HR: 26/1000Z NOT AVBL

FCST SWX + 18 HR: 26/1600Z NOT AVBL

FCST SWX + 24 HR: 26/2200Z NOT AVBL

RMK: SOLAR FLARE EVENT IN PROGRESS IMPACTING HF COM ON DAYLIGHT SIDE. IF DIFFICULTIES TRY HIGHER HF COM FREQUENCIES

NXT ADVISORY: WILL BE ISSUED BY 20221026/0400Z=



General Discussion

- Impact of Mod HF COM SWXA
 - Most airlines use this for info only and will uplink to impacted aircraft;
 - Some regional operators use HF COM constantly – will try changing primary and secondary HF channels where there are issues.
 - Some operators felt ATC broadcast of MOD HF outages would be beneficial for situational awareness
- Impact of Sev HF COM SWXA
 - Most larger operators have an alternate comms solution (e.g. SatComm)
 - Real-time internal risk assessment would be conducted (Qantas)
 - Departure of HF only aircraft may not occur



General Discussion

- Radiation
 - Generally limited to polar regions (south of 60S for NZ/Aus FIRs)
 - Delay the flight (pre-flight)
 - Reroute or descend to below FL280 (in flight)
 - Carry contingency fuel (over payload)
- For ATC, SWXA are simply another trigger for airline requests for route/altitude changes. The procedures are already in place.
- Agreement that it is the airlines' decision as to any actions taken on receipt of a SWXA.
- ICAO recommends that both Operational and Exercise SWXA should be disseminated in operational briefing systems. Test Advisories do not need to be disseminated beyond comm systems



Recommendations:

Airlines and ANSPs to

1. review and include Space Weather events into their contingency procedures
2. consider benefits of broadcasting MOD and SEV SWX Advisories when impacting ANSP airspace
3. ensure systems are configured to support all ICAO space weather advisory headers FNXX01-04 (initially all advisories had header FNXX01)
4. consider non-ICAO information sources to better manage risks associated with SWX events
5. Consider sending both Operational and Exercise SWXA to operational briefing systems. Test Advisories do not need to be disseminated beyond comm systems

Future activities:

1. ICAO APAC office planning a space weather webinar – dates TBC
2. Early-stage planning for future GNSS scenario exercise, with wider participation.





The Bureau
of Meteorology

Thank you

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