State Civil Aviation Agency of
the Kyrgyz Republic

SPACE WEATHER & AVIATION

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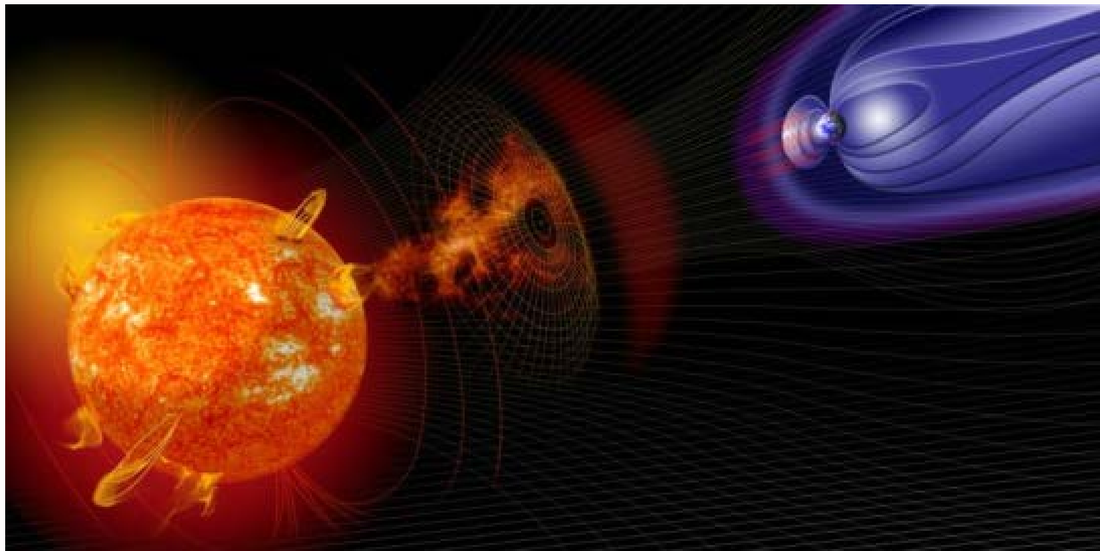
Content

What is Space Weather?

World Meteorological Organization (WMO):
“The physical and phenomenological state of the natural space environment, including the Sun and the interplanetary and planetary environments.”

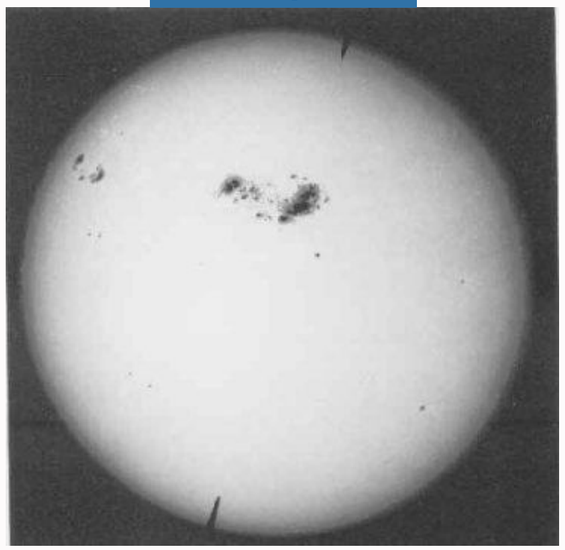
Aviation:
space weather events occur when the Sun causes disruptions to aviation communications, navigation and surveillance systems, and elevates radiation dose levels at flight altitudes

Particular types of disturbances: solar radiation, geomagnetic and ionospheric storms, solar flares and GCR

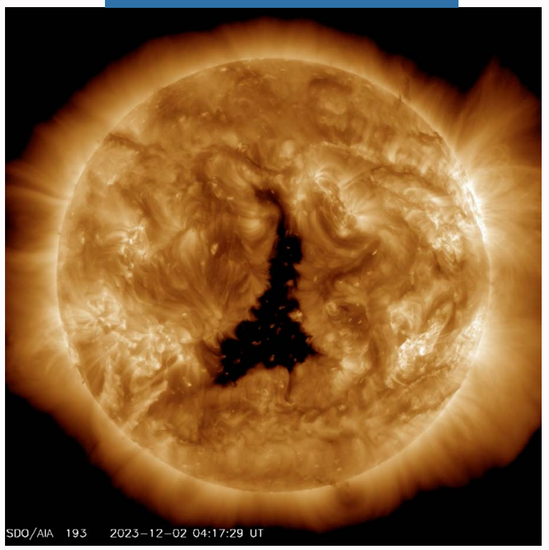


Sun’s Processes

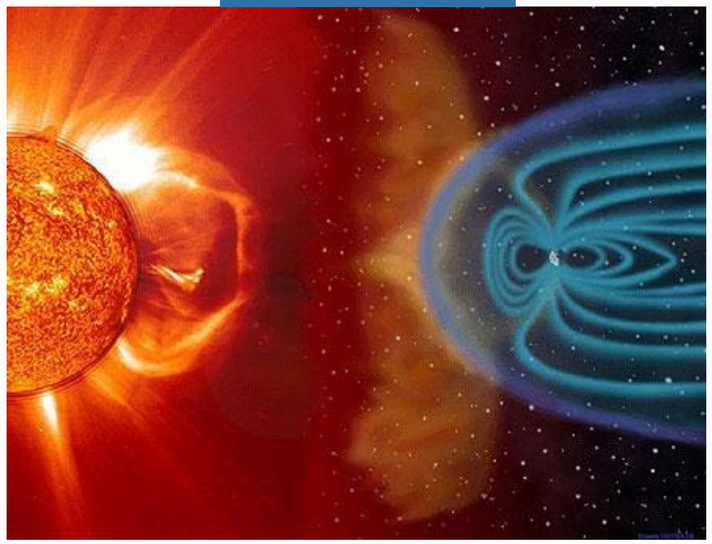
Sunspots



Coronal hole

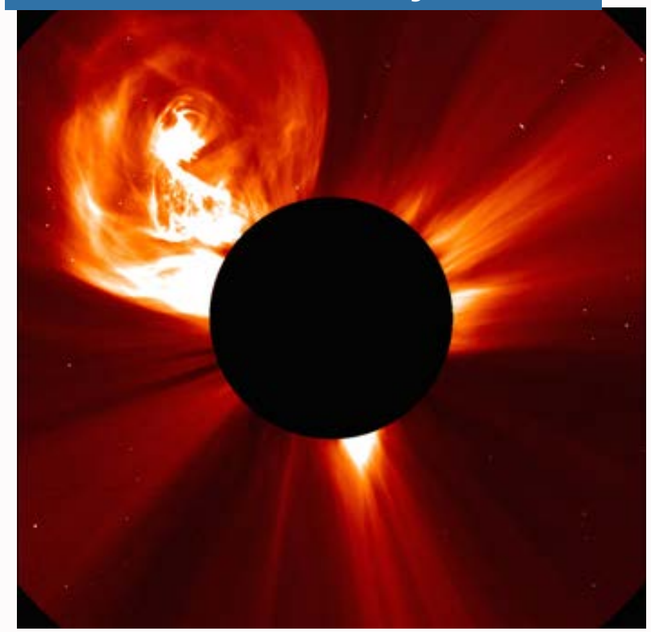


Solar wind

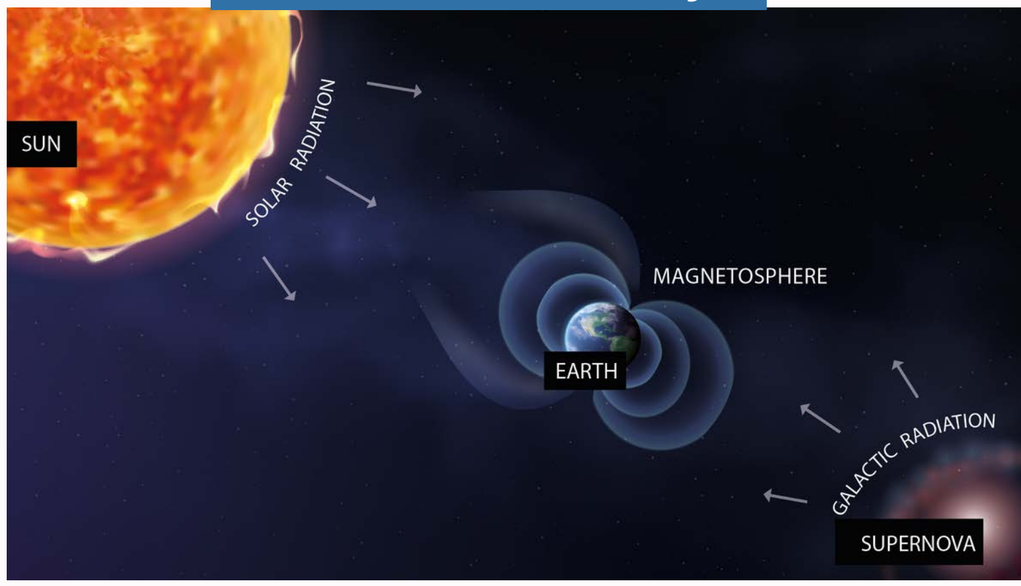


Solar flare

Coronal mass ejection



Galactic cosmic rays



Geomagnetic Storms

Strong disturbances in the Earth’s (geo) magnetic field

The strongest storms are caused by CMEs

The duration varies from a few hours to a few days

Impact HF, VHF, GNSS

Ionospheric Storms

The result of adding energy to the weakly ionized plasma which is the ionosphere

The strongest storms occur at the rate of approximately 4 per 11-year cycle

In most cases occur in tandem with geomagnetic storms

The primary driver for impacts to HF and the GNSS

Solar Flare Radio Blackouts

A dayside impact

The worst solar flare radio blackouts occur at a rate of 1-2 per 11-year cycle

10-20 episodes of solar flare radio blackout during solar maximum years

1) Can eliminate or degrade HF, both voice and data link.
2) Affect HF and UHF radars

Solar Radiation Storms

Occur when charged particles engulf the Earth with additional radiation

Can last up to a week

High altitude, polar and near-polar flights are the most exposed

1) Degrade HF at high latitudes
2) Elevate the radiation dose experienced in flight

Space Weather Impacts on Aviation

1) *erratic, degraded, or unavailable HF;*

2) *data and voice dropouts on SATCOM;*

3) *degraded performance of navigation and surveillance that rely on GNSS;*

4) *reboots and anomalies of on-board electronics;*

5) *radiation exposure by aircrew and passengers*

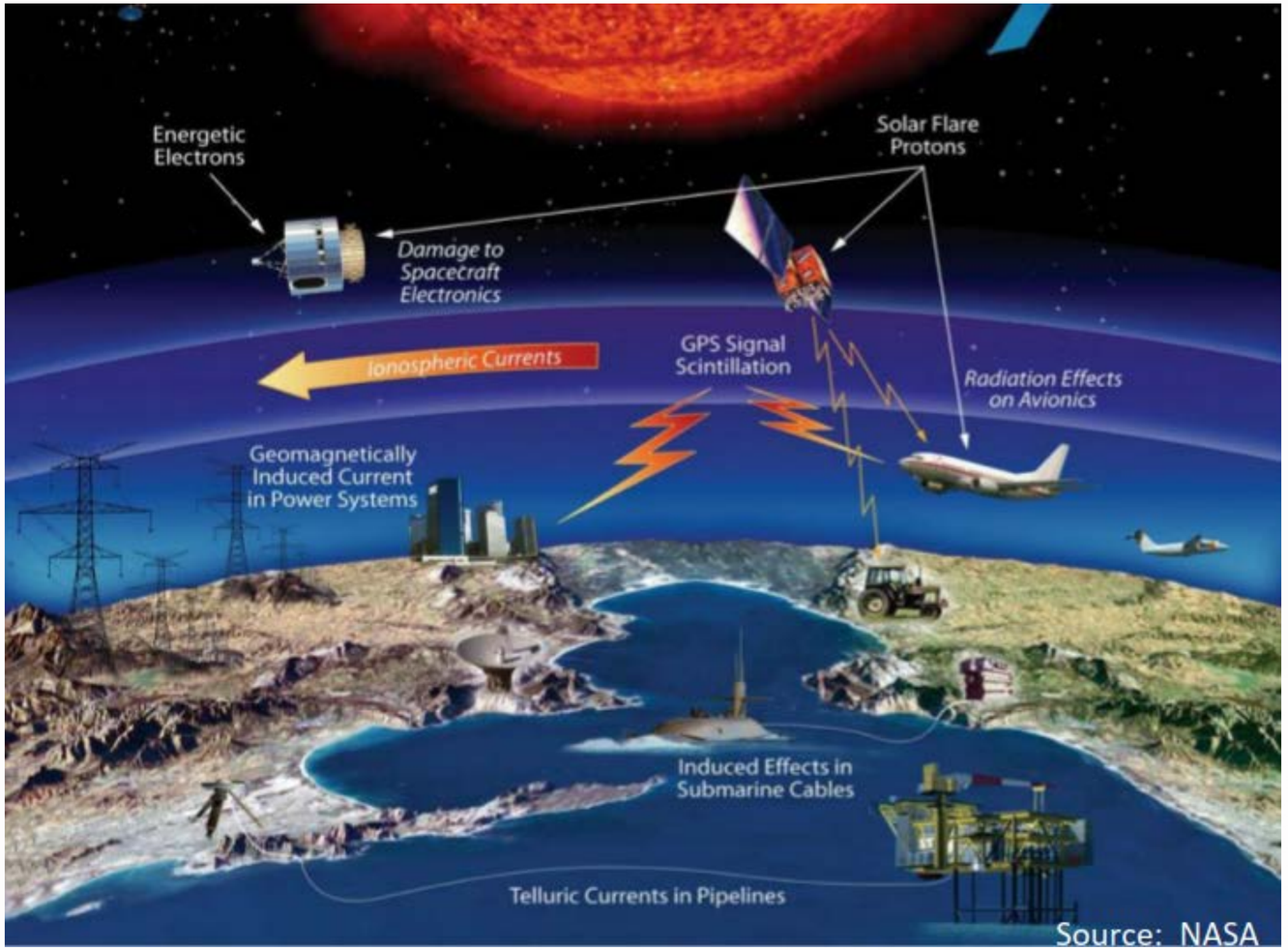
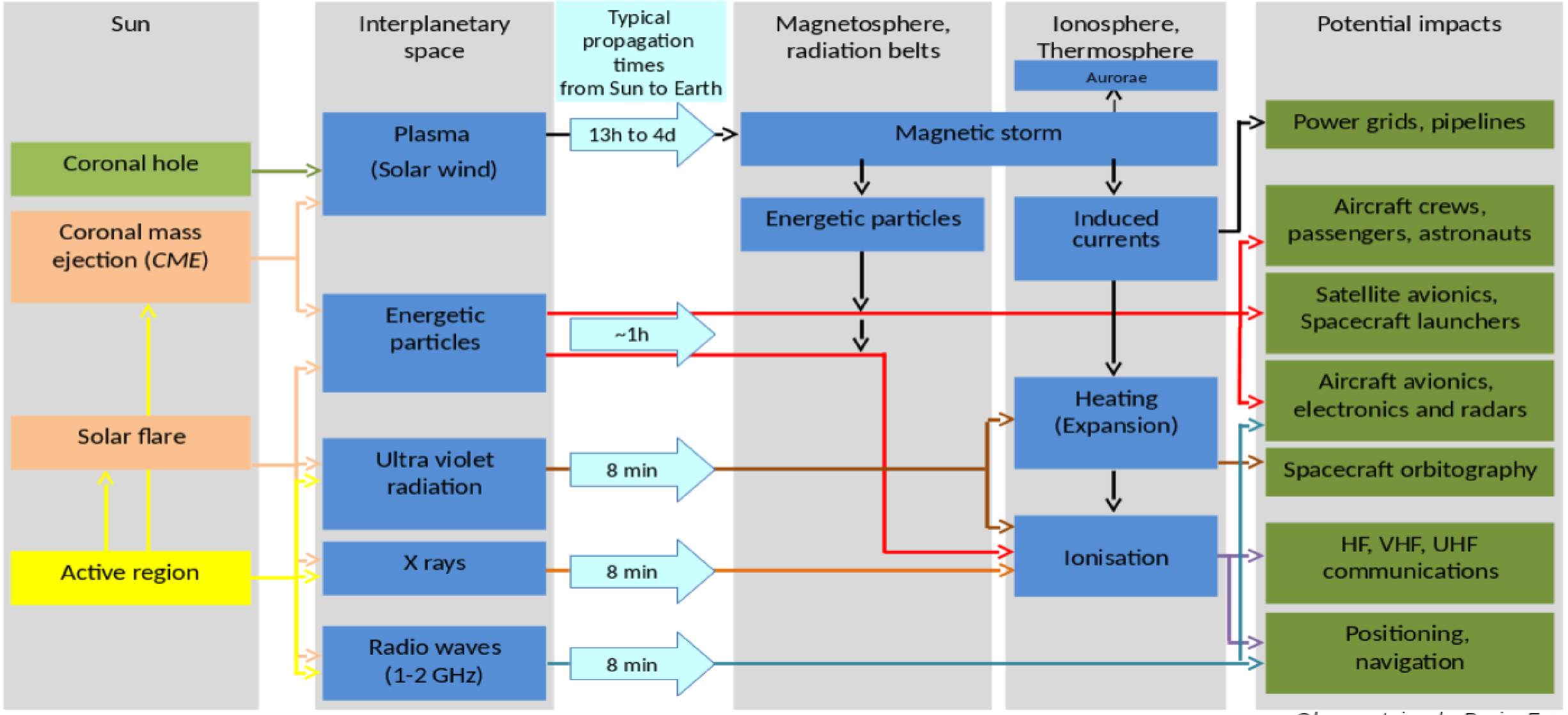


Illustration of Sun-Earth relations : colours in the first column show phenomena varying according to different timescales : coronal holes are stable for several solar rotations (27 days), active regions vary on timescales comparable to the Sun rotation period, while solar flares and mass ejections are explosive phenomena. All of these phenomena vary according to the 11 year activity cycle.



Observatoire de Paris, France

Space Weather Centers

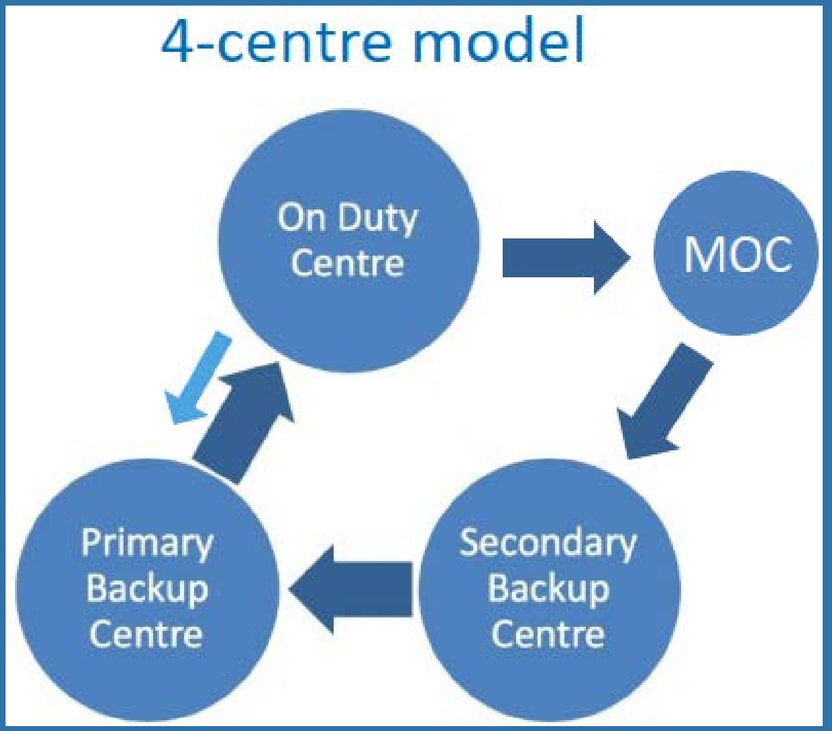
SWPC - USA

ACFJ - Australia, Canada, France, Japan

PECASUS - Finland, Belgium, UK, Austria, Germany, Italy, Netherlands, Poland, Cyprus

CRC – Russia, China

4-centre model



Handover Timetable, years 2021-2023

Month	Date	On Duty Centre	Primary Backup Centre	Secondary Backup Centre	Maintenance and Observation Centre
May 2022	03	ACFJ	PECASUS	SWPC	CRC
	17	PECASUS	SWPC	CRC	ACFJ
	31	SWPC	CRC	ACFJ	PECASUS
June	14	CRC	ACFJ	PECASUS	SWPC
	28	ACFJ	PECASUS	SWPC	CRC
July	12	PECASUS	SWPC	CRC	ACFJ
	26	SWPC	CRC	ACFJ	PECASUS
Aug	09	CRC	ACFJ	PECASUS	SWPC
	23	ACFJ	PECASUS	SWPC	CRC
Sep	06	PECASUS	SWPC	CRC	ACFJ
	20	SWPC	CRC	ACFJ	PECASUS
Oct	04	CRC	ACFJ**	PECASUS**	SWPC
	18	ACFJ	PECASUS**	SWPC**	CRC
Nov	01	PECASUS	SWPC**	CRC**	ACFJ
	15	SWPC	CRC**	ACFJ**	PECASUS
	29	CRC	ACFJ	PECASUS	SWPC
Dec	13	ACFJ	PECASUS	SWPC	CRC
	27	PECASUS	SWPC	CRC	ACFJ
Jan 2023	10	SWPC	CRC	ACFJ	PECASUS
	24	CRC	ACFJ	PECASUS	SWPC
Feb	07	ACFJ	PECASUS	SWPC	CRC
	21	PECASUS	SWPC	CRC	ACFJ
Mar	07	SWPC	CRC**	ACFJ**	PECASUS
	21	CRC	ACFJ**	PECASUS**	SWPC

** Exercise of unplanned handover

Role&Responsibility of the SWXC

01

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 HF, SATCOM, GNSS and RADIATION

02

Issue advisory information regarding the extent, severity and duration of the space weather phenomena

03

Supply the advisory information to:

- area control centres, flight information centres and meteorological offices;
- other SWXCs;
- OPMET databanks.

Space Weather Advisory Message - Examples

HF Communication

SWX ADVISORY	
DTG:	20201108/0100Z
SWXC:	DONLON*
SWX EFFECT:	HF COM
ADVISORY NR:	2020/1
OBS SWX:	08/0100Z SEV MNH EQN EQS MSH DAYSIDE MOD NIGHTSIDE
FCST SWX +6 HR:	08/0700Z NO SWX EXP
FCST SWX +12 HR:	08/1300Z NO SWX EXP
FCST SWX +18 HR:	08/1900Z NO SWX EXP
FCST SWX +24 HR:	09/0100Z NO SWX EXP
RMK:	SWX EVENT IMPACTING LOWER HF COM FREQ BAND. SEE WWW.SPACEWEATHERPROVIDER.WEB
NXT ADVISORY:	WILL BE ISSUED BY 20201108/0700Z

* Местоположение условное

GNSS

SWX ADVISORY	
DTG:	20201108/0100Z
SWXC:	DONLON*
SWX EFFECT:	GNSS
ADVISORY NR:	2020/2
NR RPLC:	2020/1
OBS SWX:	08/0100Z MOD HNH HSH W180 – E180
FCST SWX +6 HR:	08/0700Z MOD HNH HSH W180 – E180
FCST SWX +12 HR:	08/1300Z NO SWX EXP
FCST SWX +18 HR:	08/1900Z NO SWX EXP
FCST SWX +24 HR:	09/0100Z NO SWX EXP
RMK:	SWX EVENT INPR POSSIBLY IMPACTING GNSS PER. AREA OF IMPACT MOVES WITH EARTH'S ROTATION, STAYING STRONGER ON NIGHTSIDE. EXP TO SUBSIDE IN THE FCST PERIOD. SEE WWW.SPACEWEATHERPROVIDER.WEB
NXT ADVISORY:	WILL BE ISSUED BY 20201108/0700Z

* Местоположение условное.

Radiation

SWX ADVISORY	
DTG:	20201108/0100Z
SWXC:	DONLON*
SWX EFFECT:	RADIATION
ADVISORY NR:	2020/15
NR RPLC:	2020/13 2020/14
OBS SWX:	08/0100Z MOD N80 W180 - N70 W075 - N60 E015 - N70 E075 - N80 W180 ABV FL400
FCST SWX +6 HR:	08/0700Z NO SWX EXP
FCST SWX +12 HR:	08/1300Z NO SWX EXP
FCST SWX +18 HR:	08/1900Z NO SWX EXP
FCST SWX +24 HR:	08/0700Z NO SWX EXP
RMK:	08/1300Z NO SWX EXP 08/1900Z NO SWX EXP 09/0100Z NO SWX EXP RTN TO BACKGROUND LVL INSIDE THE FIRST FCST PERIOD. SEE WWW.SPACEWEATHERPROVIDER.WEB
NXT ADVISORY:	WILL BE ISSUED BY 20201108/0700Z

* Местоположение условное

SW phenomena thresholds

Effect	Sub-effect	Parameter used	Moderate	Severe
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 (micro-Sieverts/hour)	30	80
HF COM	Auroral Absorption (AA)	Kp	8	9
HF COM	Polar Cap Absorption (PCA)	dB from 30MHz riometer data	2	5
HF COM	Shortwave Fadeout (SWF)	Solar X-rays (0.0-0.8 nm) (W-m-2)	1x10-4 (X1)	1x10-3 (X10)
HF COM	Post-Storm Depression	MUF	30%	50%
SATCOM	No threshold has been set for this effect			

Space Weather Mitigation

HF radio communications:

- *switch to lower/higher HF radio frequencies during ionospheric storms/solar flares*
- *use alternate forms of communication (SATCOM or VHF)*
- *delay or re-route flights, particularly in polar regions*

GNSS navigation and surveillance:

- *increase spacing between aircraft*
- *use alternative navigation technology in impacted locations*
- *GBAS and SBAS GNSS augmentation system operators should monitor service performance and execute risk mitigation plans.*

Radiation exposure on polar routes

- *reduce altitude of polar flights*
- *re-route polar flights to lower latitudes*

Evolution of Services and Needs

- *Continue to improve forecasts – nowcasting, short-term forecasting and long-range forecasts*
- *Clear interaction between all participants – SWSXs, MET offices, flight crew and aircraft operators*

Given the chaotic, eruptive nature of the phenomena, space weather may never be like weather, but we can try

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THANK YOU

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