Disturbed Space weather

Causes	Solar flares	Proton events	Coronal Mass Ejections	Coronal Holes
Arrival	Immediately (8 min)	15 min to a few hours	20 to 72+ hours	2 to 4 days
NOAA scales	R1 (minor) => R5 (extreme) *R = Radio Blackout*	S1 (minor) => S5 (extreme) *S = Solar Radiation Storm*	G1 (minor) => G5 (extreme) *G = Geomagnetic Storm*	
Parameter	M1 => ≥ X20	Pfu (>10MeV): 10 => 10^5	Kp = 5 => Kp = 9	
Duration	Minutes to hours	Hours to days	Days	
Protection	Earth's atmosphere	Earth's magnetic field	Earth's magnetic field	

Effects			
Radio communications *(SID, short wave fadeout)*	Satellites *(SEE, solar arrays, ageing, star trackers)*	Satellites *(Orientation, drag, charging)*	
Radar interference	Astronauts & Airplanes *(Radiation Dose)*	Aurora	
Navigation & Airplanes *(GPS, radar)*	Communication/Navigation	Communication/Navigation	
	Ground Level Enhancement	Electrical Currents (GIC) *(Long conductors, power grids, pipelines)*	

Storm Type	Travel time	Physical Impact	Technological Impact
Geo-magnetic	18-96h	· Geomagnetic induced currents · increased ionisation in ionosphere · heating in the thermosphere	· Power grid outages, etc · GNSS, HF comms · Satellite and other hardware damage (eg surface charging) · Satellite orbits (drag, collision risk) · HF comms
Charged particles	10mins – 1 day	· increased radiation levels · damage to sensitive electronics increased · ionisation in ionosphere	· Radiation health hazard (astronauts, aircrew) · Satellite heating and instrument noise, avionics, digital chips · as above - HF comms out for up to few days in polar regions
Solar flares	8mins	· HF radio signal interference · heating in the thermosphere	· HF comms (~mins-hrs, sunlit side) · As above

Image from MET Office
https://www.metoffice.gov.uk/weather/learn-about/space-weather/what-is-space-weather

ANNEX D: Solar phenomena and their impacts

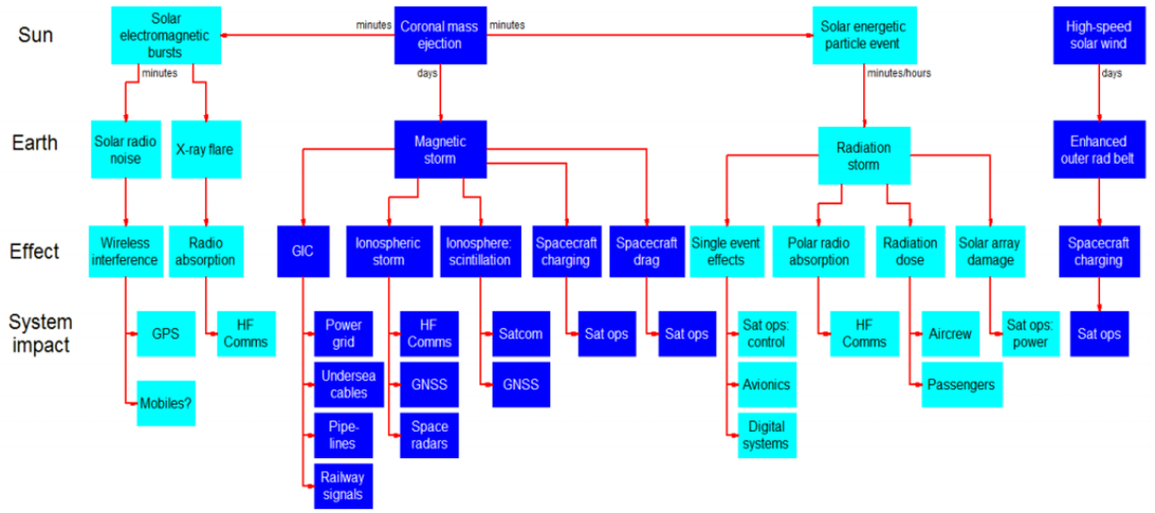
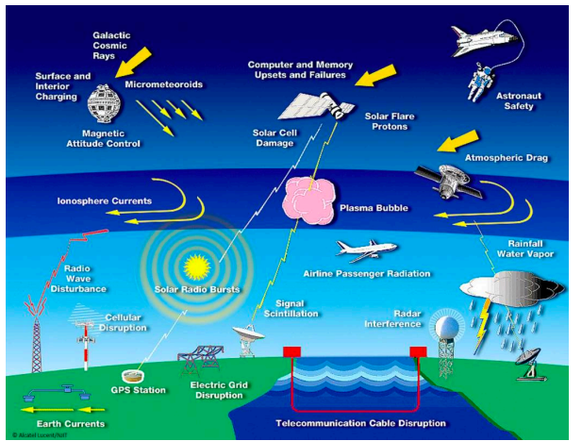
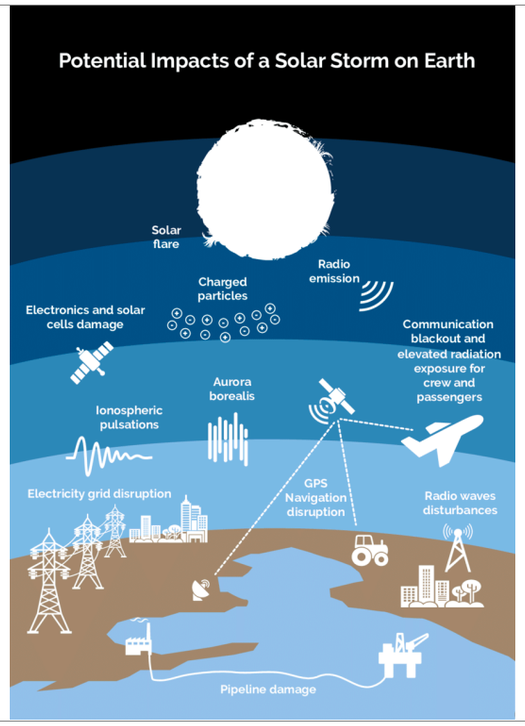
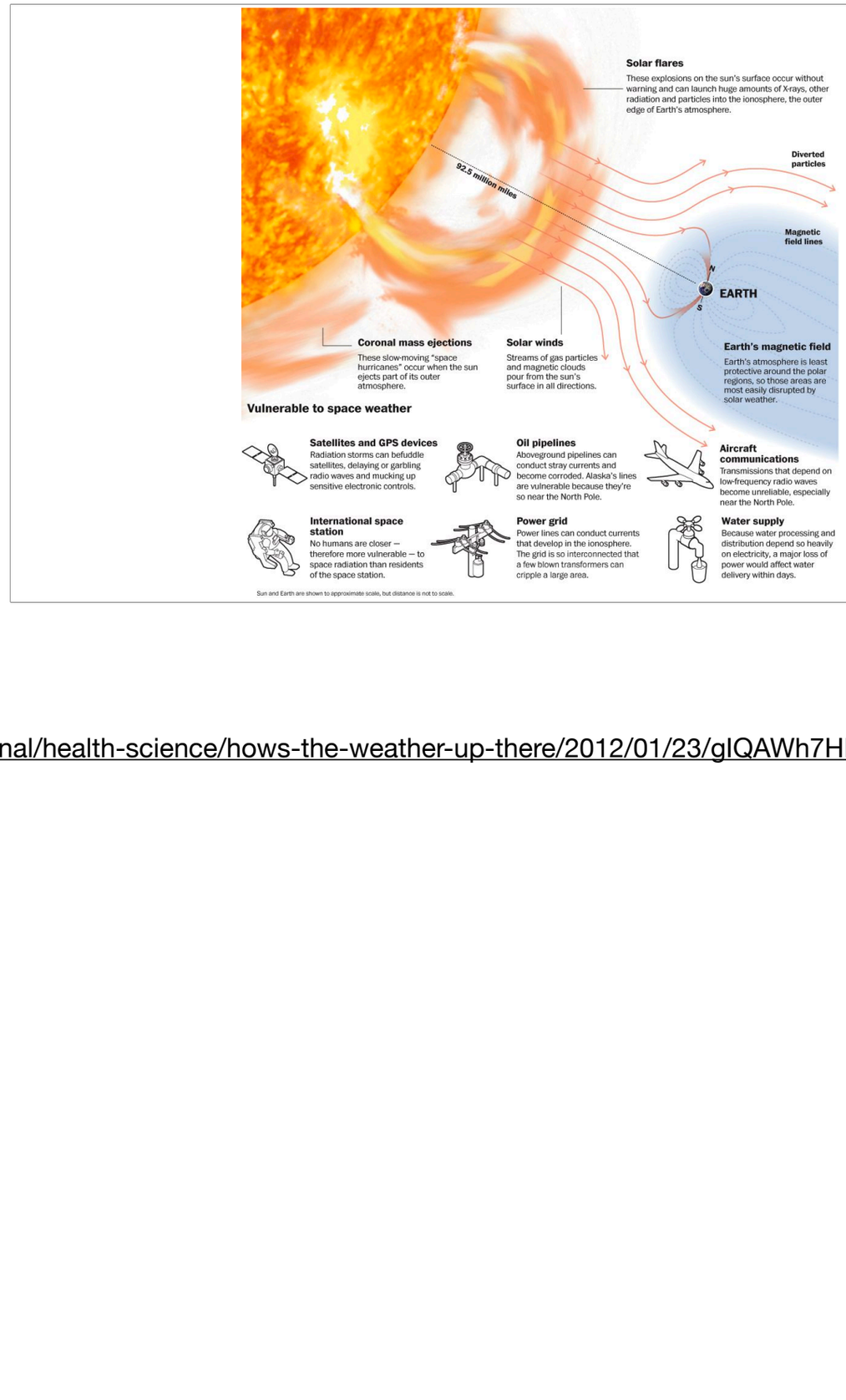


Image taken from a Policy Paper on the Space Weather Preparedness Strategy by the UK Department for Business, Innovation and Skills
https://www.gov.uk/government/publications/space-weather-preparedness-strategy





From NASA: https://www.nasa.gov/mission_pages/sunearth/news/gallery/agu11-spaceweather.html
And
The Flare Likelihood and Region Eruption Forecasting (FLARECAST) Project: Flare forecasting in the big data & machine learning era, Georgoulis et al., 2021



https://www.washingtonpost.com/national/health-science/hows-the-weather-up-there/2012/01/23/gIQAWh7HLQ_graphic.html