



In loving memory of Dr Lee-Anne McKinnell



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Space Weather: Understanding societal and economic impact

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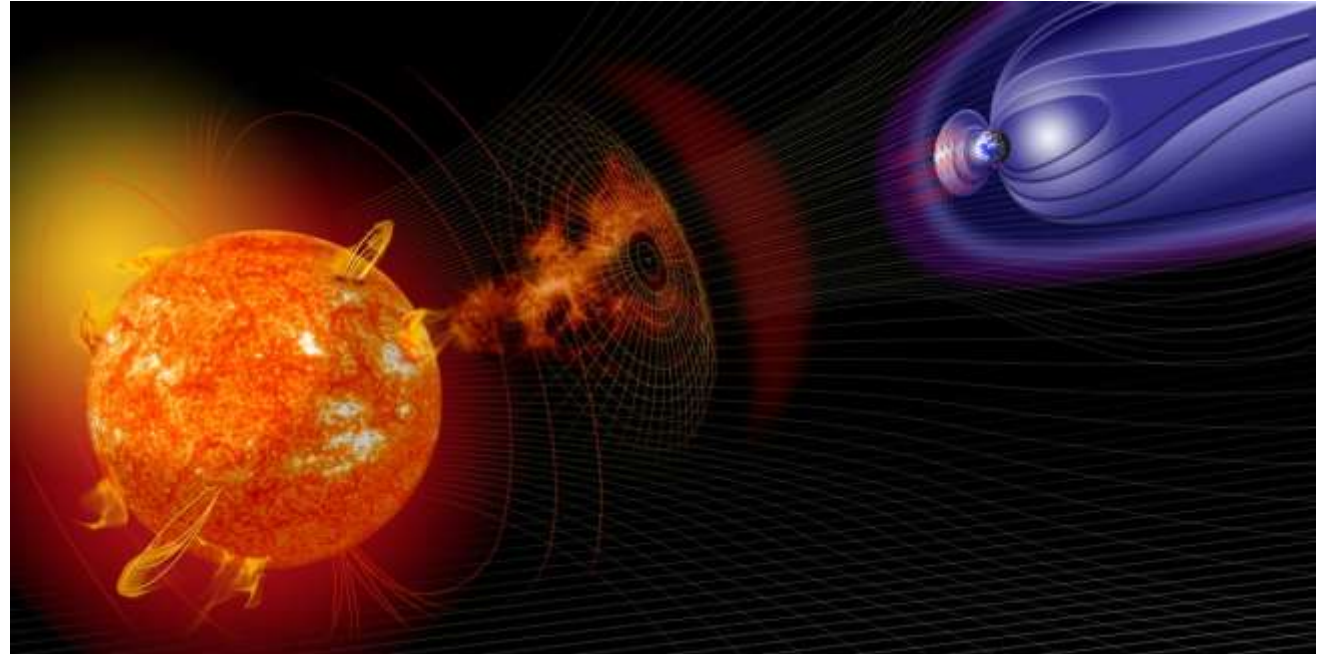
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What is Space Weather

Space Weather refers to **conditions on the Sun** and in the solar wind, magnetosphere, ionosphere, and thermosphere that can **influence the performance and reliability** of space-borne and ground-based **technological systems**.

Space weather is a consequence of the behaviour of the sun, the nature of Earth's magnetic field and atmosphere, and our location in the solar system.



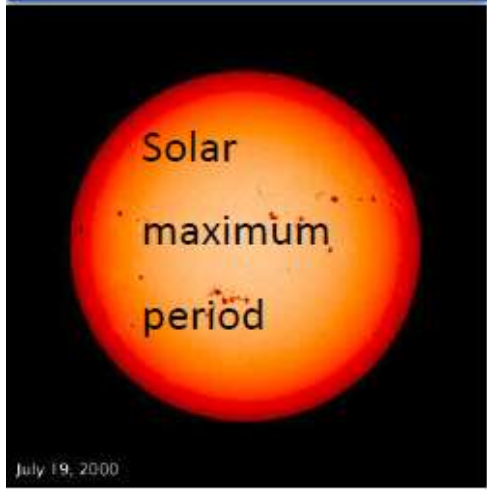
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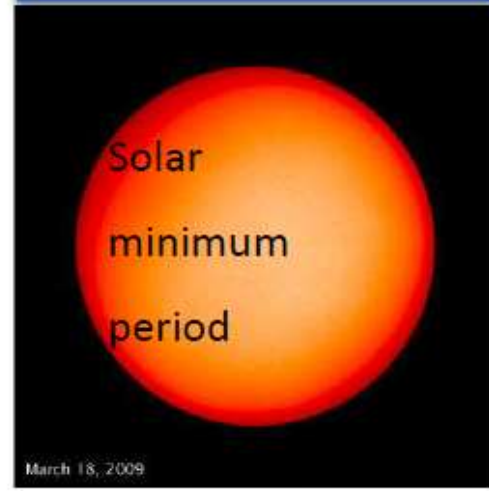


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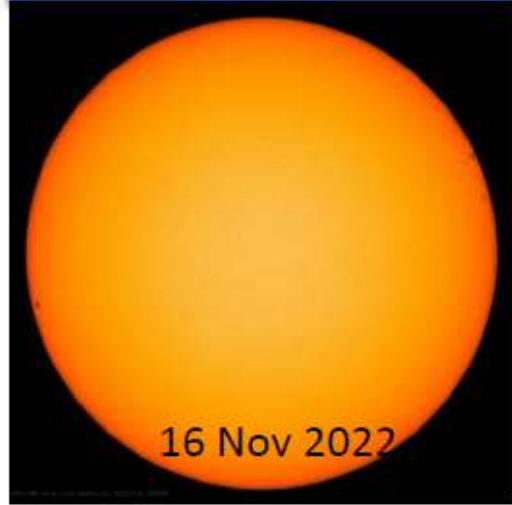
ACTIVE SUN



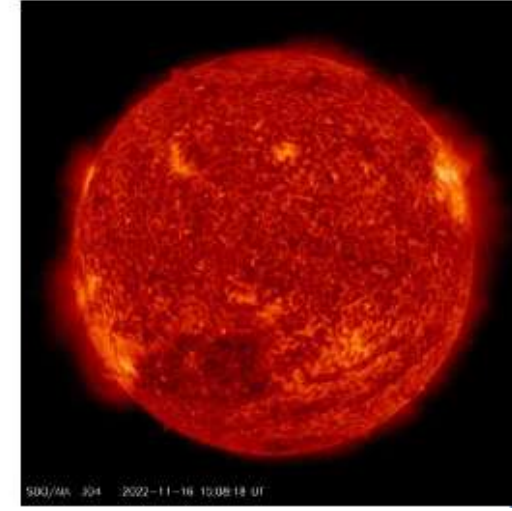
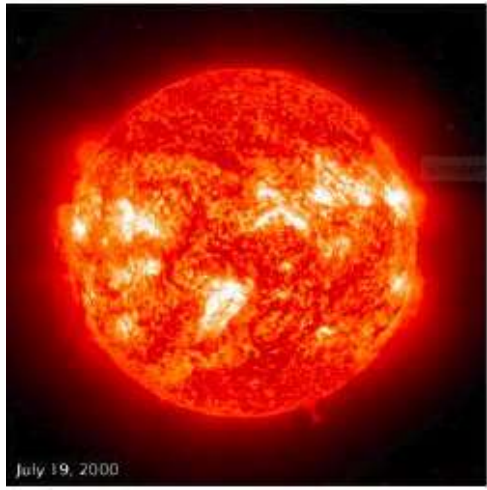
QUIET SUN



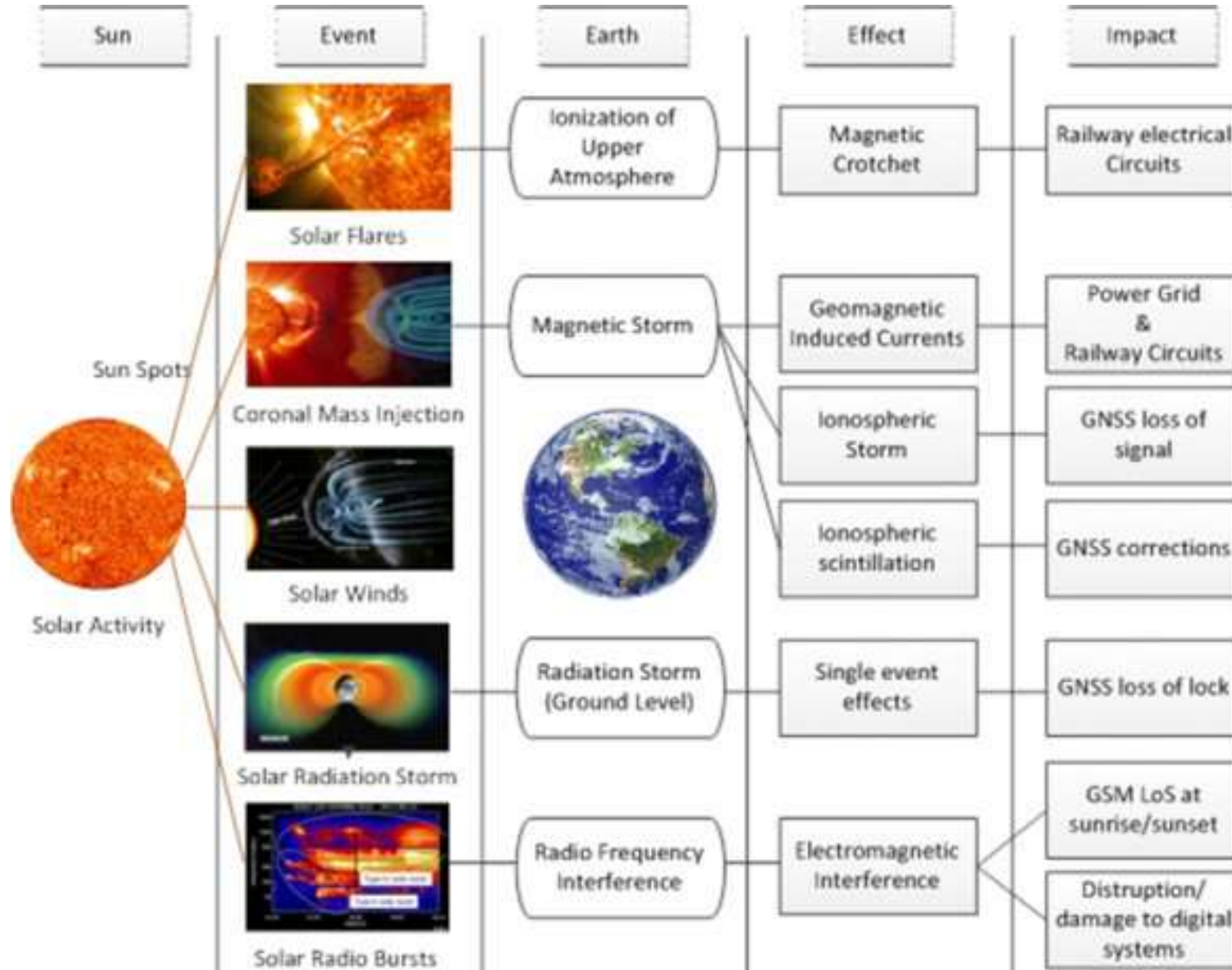
NOW SUN



Ultraviolet



Space weather impact



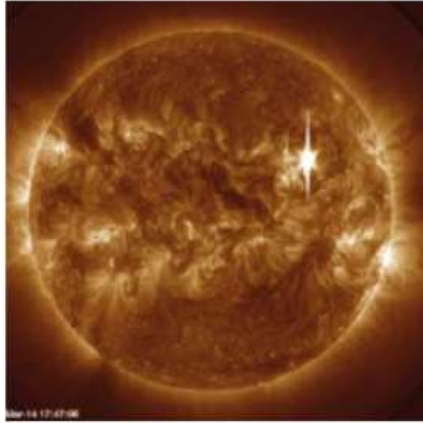
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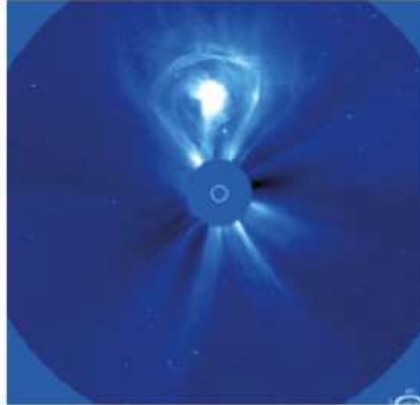
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Flares



- atmospheric heating
- ionospheric changes
- HF communication problems

Coronal mass ejections



- geo-magnetic storms
- electricity network interruptions
- possibility of cascading failures
- GNSS errors

Solar energetic particles

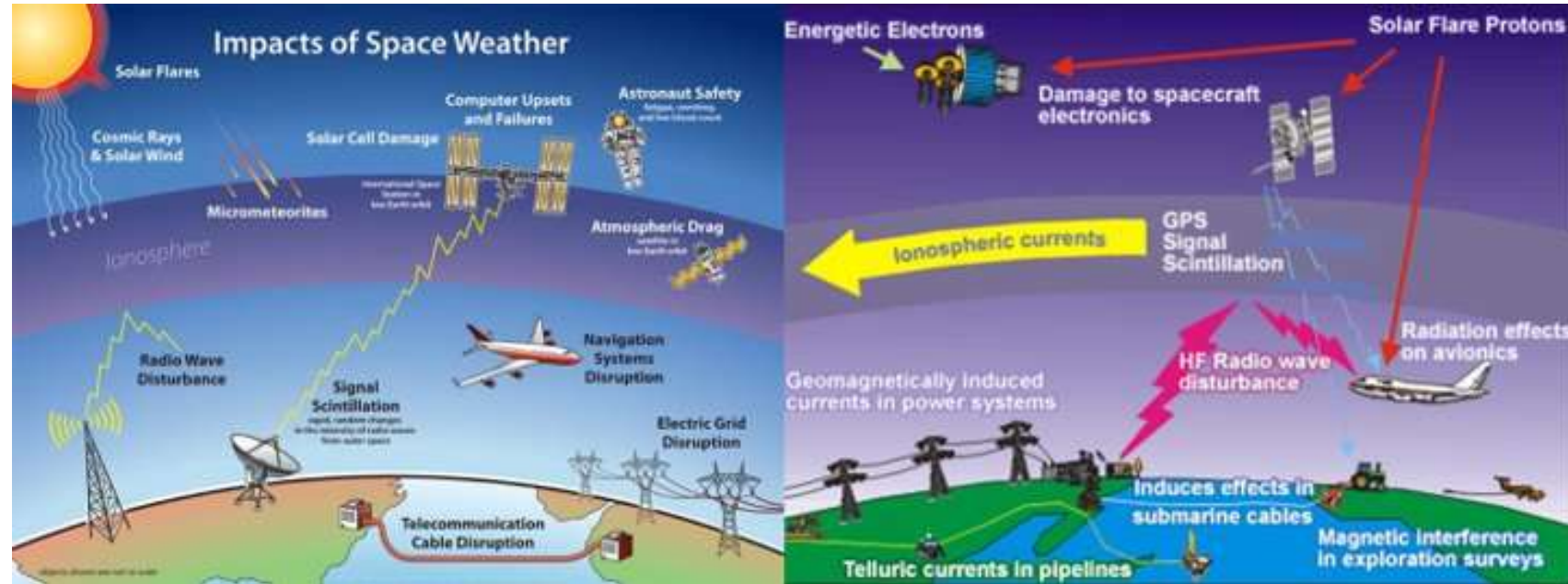


- ionising radiation at aircraft altitudes
- damage to spacecraft and aircraft electronics
- HF communication problems

Space weather keywords

- **Solar flare:**
a sudden burst of radiation including X-rays and UV from a localised region in the Sun's atmosphere.
- **Solar wind:**
a constant but gusty outward flow of material into the Solar System.
- **Coronal mass ejection:**
an ejection of electrically charged gas and magnetic field.
- **Solar energetic particles:**
high-energy electrically charged particles that can travel with speeds close to the speed of light.
- **Geomagnetic storm:**
temporary disturbance to the Earth's magnetic field.
- **Solar cycle:**
the rise and fall of solar activity levels over an (approximately) 11-year timescale. Large space weather events can occur at any phase of the cycle.

WHY SHOULD WE CARE



- ✓ Technology continues to play an ever-increasing role in our society and the potential for space weather to impact our daily lives and the economy is growing.
- ✓ Technological infrastructure, including the power grid, transport systems, communication, and electronic systems are vulnerable to space weather effects caused by the Sun

Sectors that can be impacted by Space weather

Aviation – Communications, Navigation, Avionics, Radiation Exposure

Maritime – Marine Navigation for shipping; accurate positioning, speed and heading; Vessel traffic monitoring; Marine communications

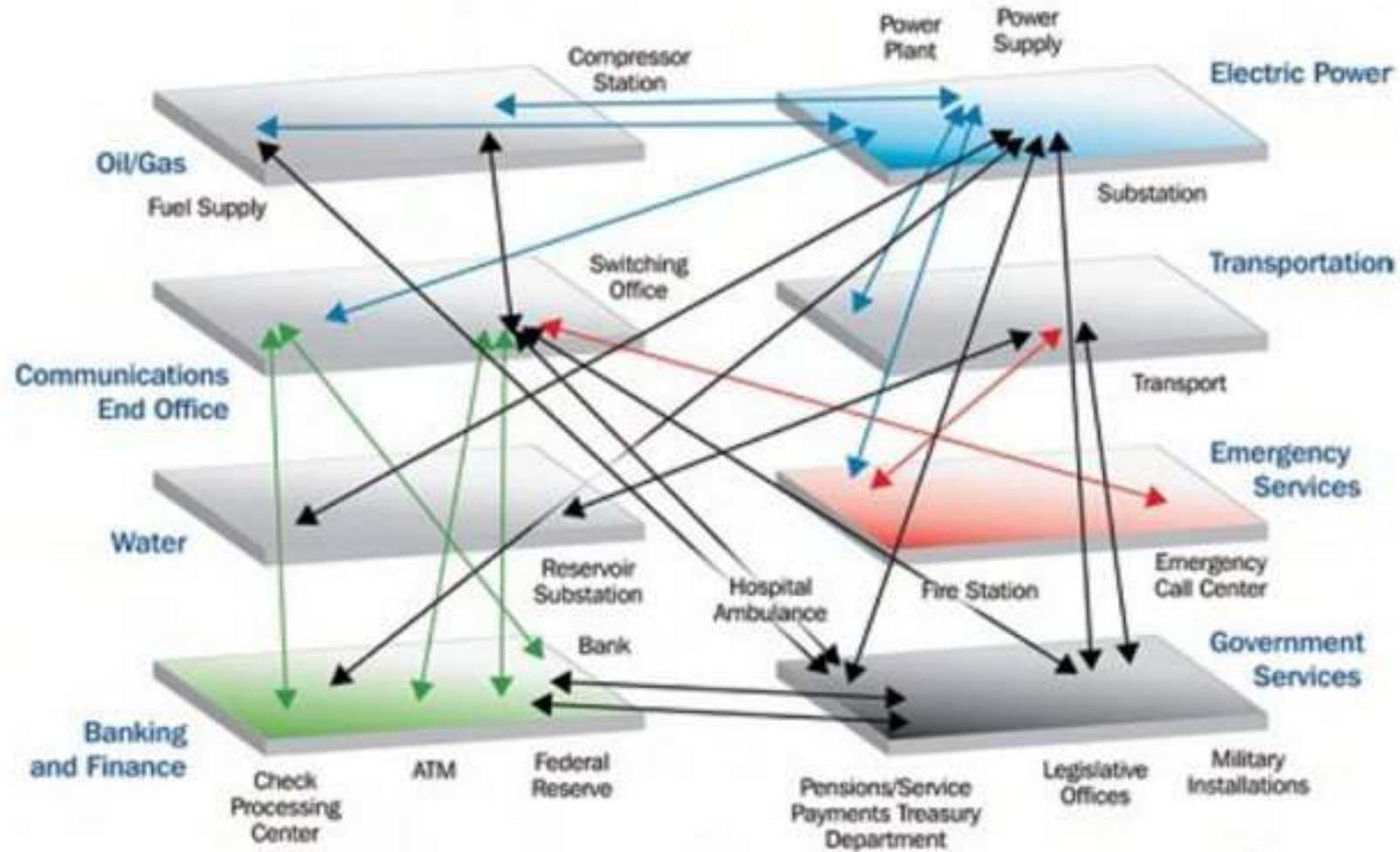
Public – Navigation; Communication; Safety & Security Systems

Rail – power; communications; navigation; signaling; train traction

Roads – Navigation;

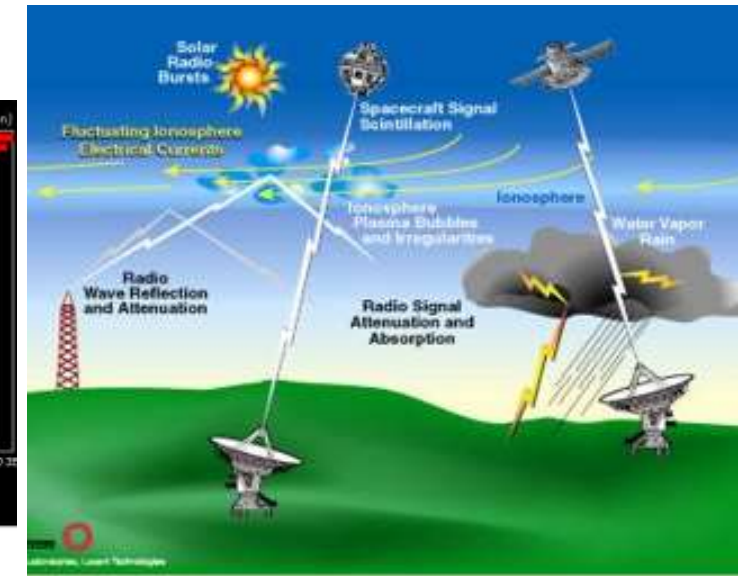
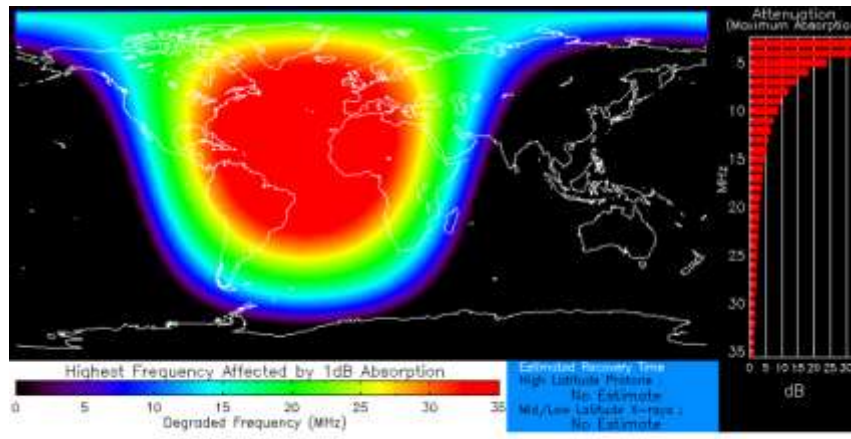
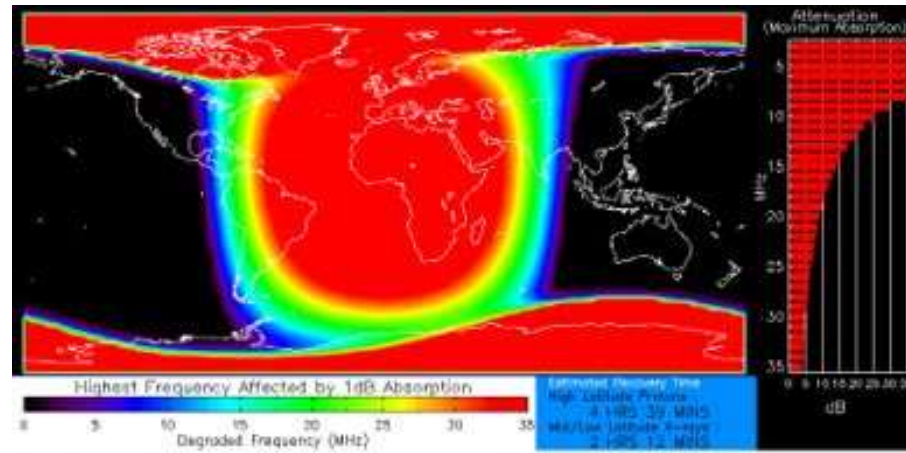
Agriculture- Communication, power, degradation of satellite images used for crop monitoring

Space weather impact: Interdependencies



Space weather can lead to a cascade of catastrophic failures of power supply, emergency services, water, satellite communication, transportation, financial, and other essential infrastructure.

Impact on HF Communications



Strong X-ray flux
Product Valid At : 2017-09-06 12:00 UTC

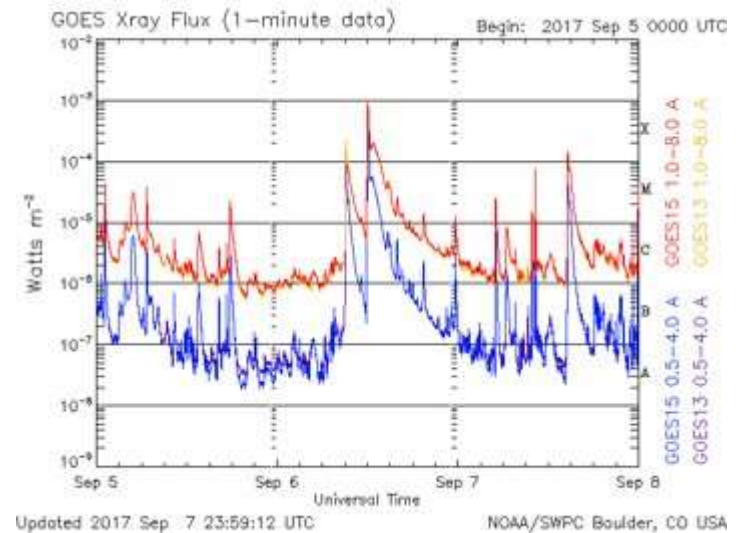
Minor Proton Flux
NOAA/SWPC Boulder, CO USA

Strong X-ray flux
Product Valid At : 2022-05-10 13:57 UTC

Normal Proton Background
NOAA/SWPC Boulder, CO USA

D-region absorption (D-RAP)

- The D-region of ionosphere has largest effect on highest frequency (HF) Comms and low frequency (LF) navigation systems. The map indicates an area of the ionospheric D-region absorption during a solar flare event as well as the estimated recovery time.
- The solar flare on the sunlit side degrade the HF radio communication and this can last anything between few minutes to hours
- In 2017 during the event NOAA reports that high frequency radio, used by aviation, maritime, ham radio, and other emergency bands, was unavailable for up to eight hours. For example, civil aviation reported a 90-minute loss of communication with a cargo plane.
- Many of these flares will produce HF radio wave absorption across the sunlit side of the Earth - strong absorption in the case of X flares.
- Mariners, Aviators, and Harm radio operators are all affected by this spac.



Updated 2017 Sep 7 23:59:12 UTC

NOAA/SWPC Boulder, CO USA



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Example of systems that uses GPS/GNSS Systems

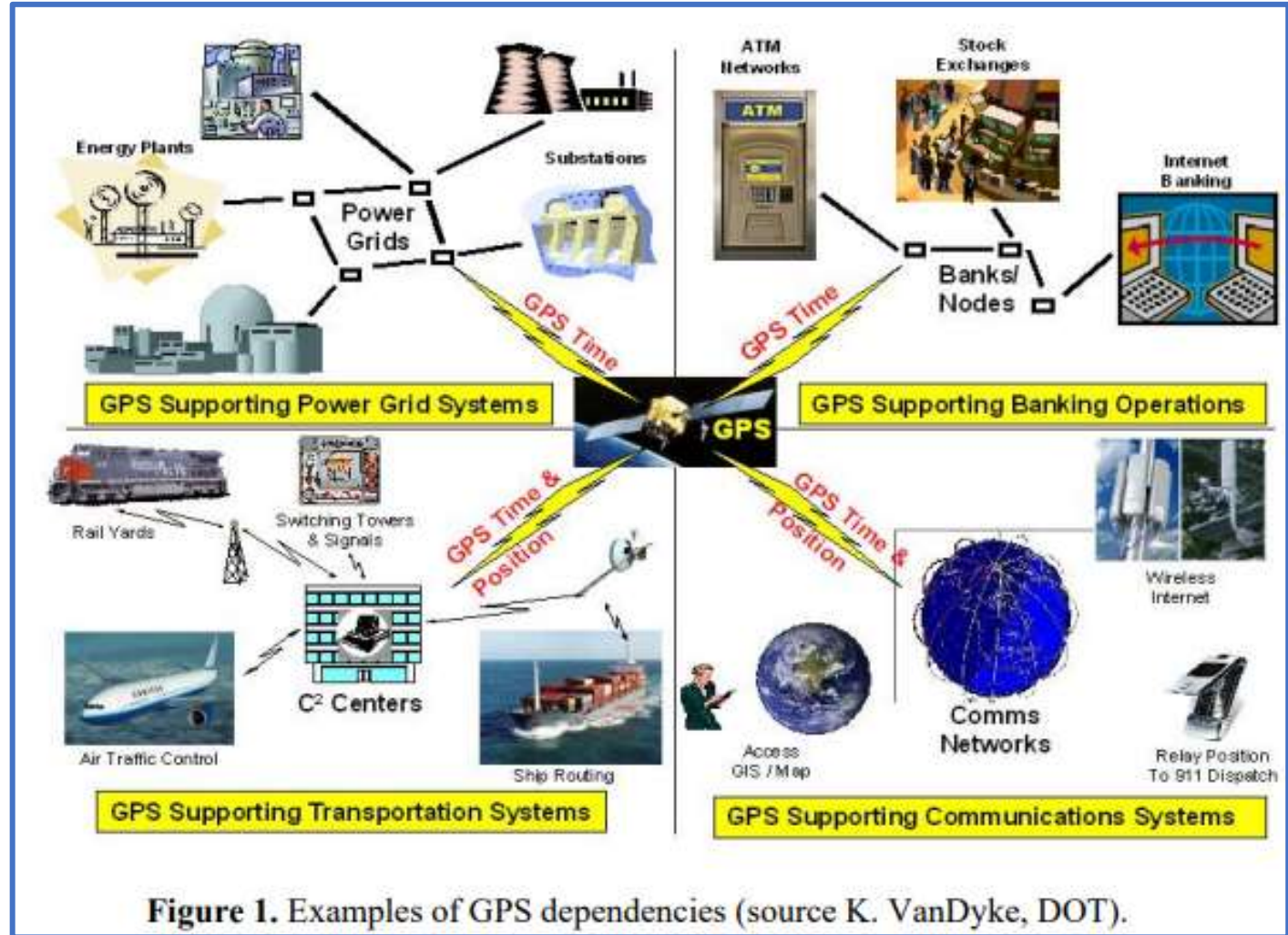
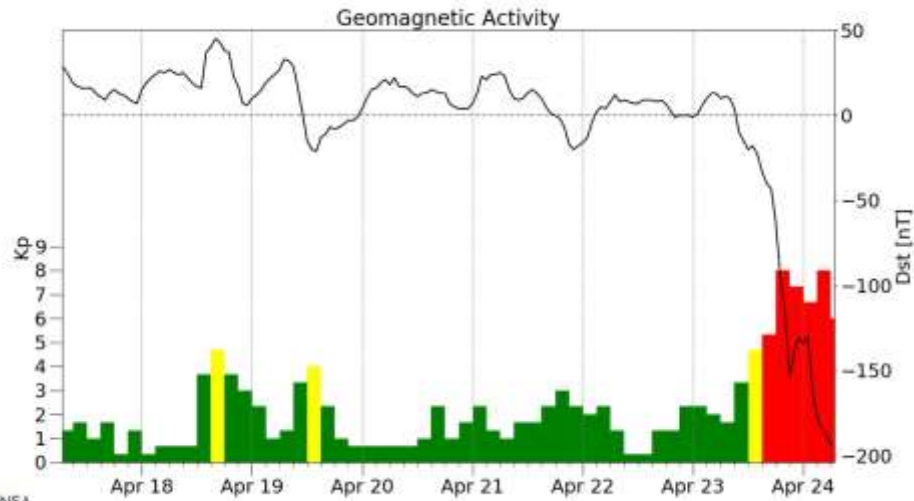
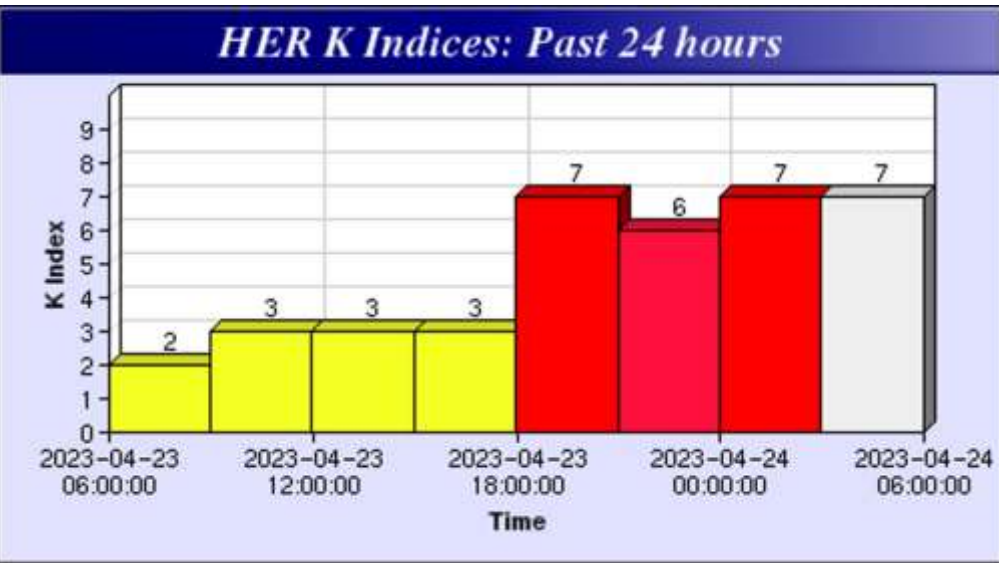
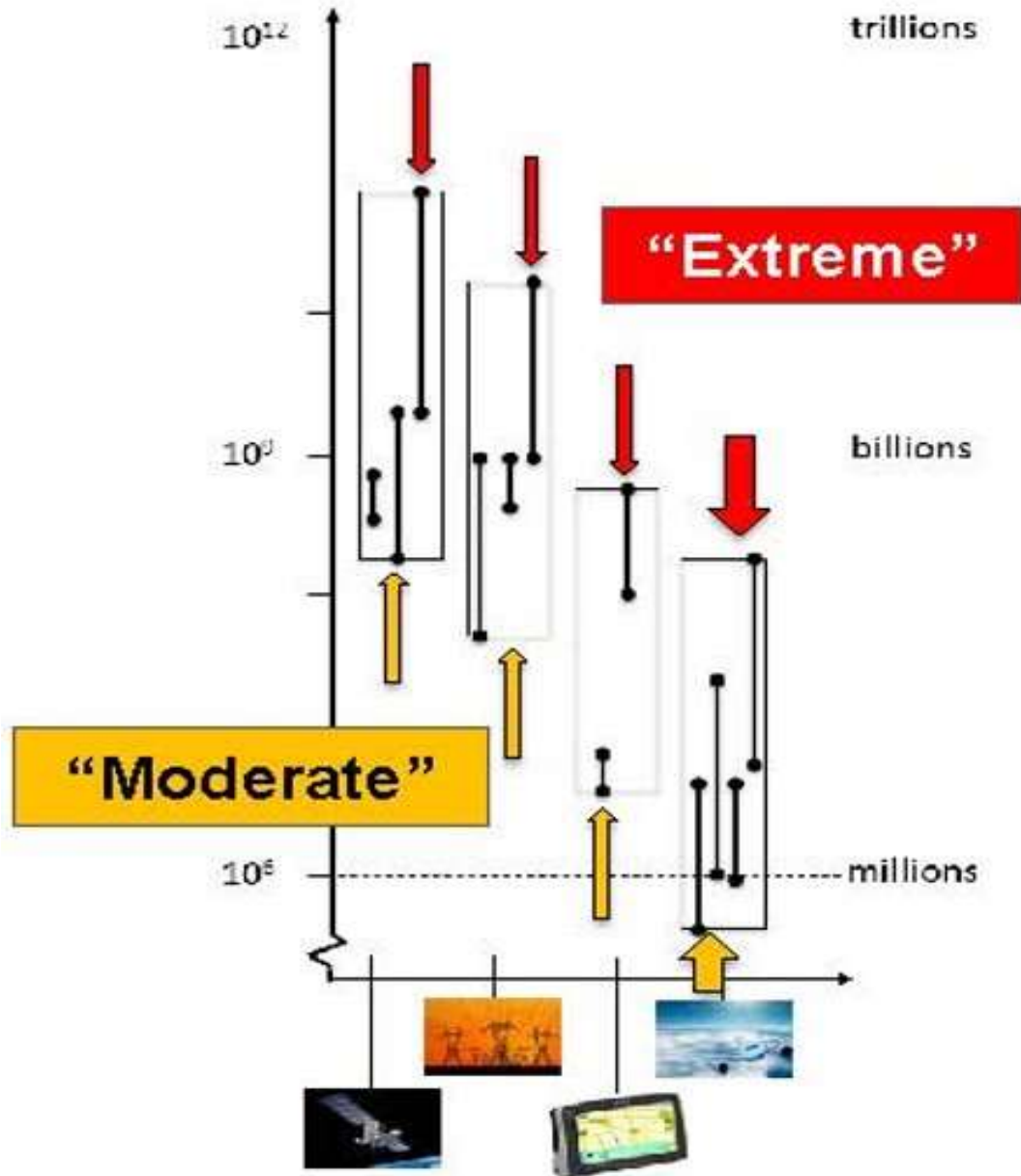


Figure 1. Examples of GPS dependencies (source K. VanDyke, DOT).



ECONOMIC IMPACT OF SPACE WEATHER



Satellite Technology

- cost of engineering & loss of applications
- Moderate , 1 satellite
- Extreme , 10 – 100 satellites

Energy

- Wide-spread blackouts
- Moderate , R 600 million in losses
- Extreme , R 1 – R 2 trillion in losses
- Recovery could be 4 – 5 years

Communication & Navigation

- Loss of GNSS capability
- GNSS outage could cost \$1 billion / day
- Can have devastating social and economic repercussions

Security

- Radio blackout in all cases

- Severe economic repercussions

Transport

- aviation, rail, maritime

SPACE WEATHER SOLUTIONS

- ✓ Provision of space weather information and forecasting
- ✓ Expertise and prediction in HF communications
- ✓ Information related to impacts on navigation applications
- ✓ Space Weather research into impacts and forecasting
- ✓ Needs analysis and impact studies
- ✓ Advice and information on how to best utilise space weather information to mitigate the impacts
- ✓ Space Weather Training for industry



24/7 Operational Space Weather Centre

CONCLUSION

- Space Weather events can create vulnerabilities within our technology dependencies, and is a risk to the 4IR
- SANSA has established an operational capability for Space Weather information provision and Magnetic Technology services for the African region
- SANSA is able to provide unique solutions on the African continent to space and non-space sectors solving challenges in safety and security, maritime, energy, transport, agriculture and mining
- SANSA looks forward to working with these sectors to enable the mitigation of risks from the near-Earth space environment

THANK YOU

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