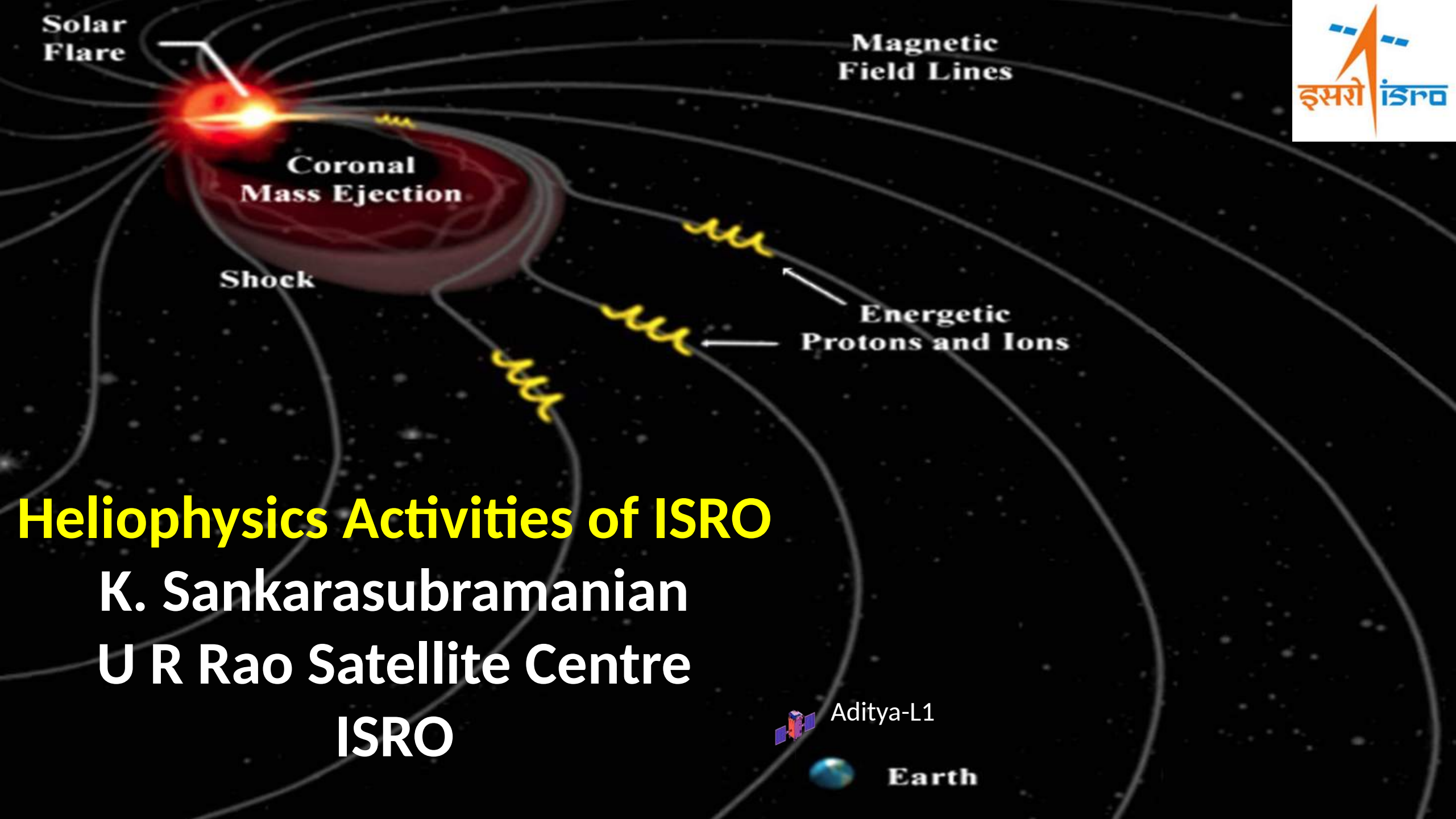


Heliophysics Activities of ISRO

K. Sankarasubramanian
U R Rao Satellite Centre
ISRO

Heliophysics in India-Early activities

Madras Observatory (1786-1899)

- Observational aspects initiated as early as 1786.
- Kodaikanal Observatory – first dedicated solar observatory in India established in 1899 (pioneering observations including the Evershed Effect)
- Currently this observatory carries out: synoptic observations of H-alpha, CaK, white light images; Spectroscopy, spectropolarimetry & spectroheliograms.

http://www.iiap.res.in/kodai.htm

http://www.iigm.res.in/alibag.htm

Space Weather:

- Geomagnetic observations in Colaba observatory in 1841.
- First geomagnetic observatory in the world in Trivandrum in 1852.
- Earliest record of space weather events Feb 4, 1872.
- From 1905 to today magnetic recordings from Alibag Magnetic Observatory.

Heliophysics in India- Major ground based activities

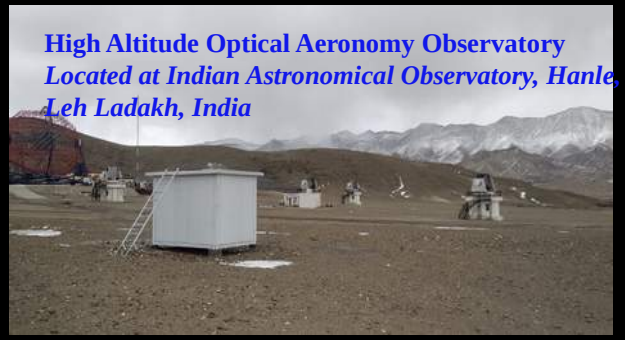
Various ground measurements for solar science and space weather

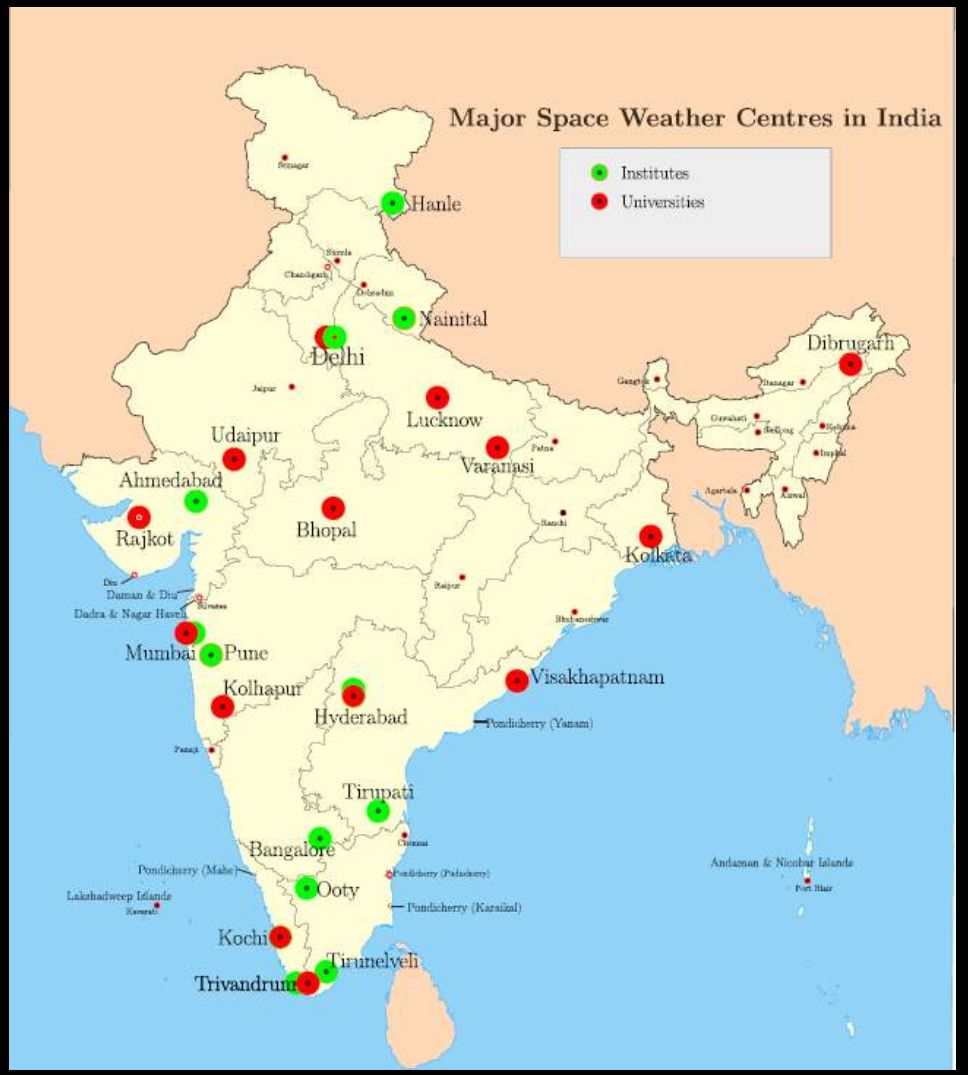
- Solar images in various optical wavelengths
- Solar Dopplergram images
- Solar spectral and magnetogram images
- Solar Radio Imaging & Solar radio bursts
- Solar Radio Observations
- (80-1750 MHz)
- Solar Wind measurements IPS
- Geomagnetic field variations
- GNSS receivers
- Radar interferometers
- Digital ionosonde
- Digisonde DPS-4D
- CADI ionosondes
- All sky airglow imager

Various other ground based sensors

Major observatories for solar observation

H-alpha telescope, ARIES

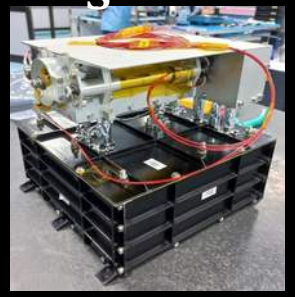




Heliophysics in India-Current activities

Space based measurements (in-orbit):

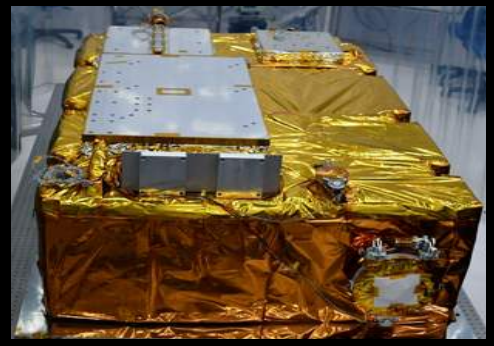
SoLEXS



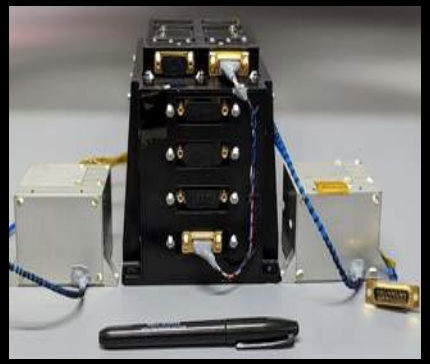
HEL1OS

SUIT

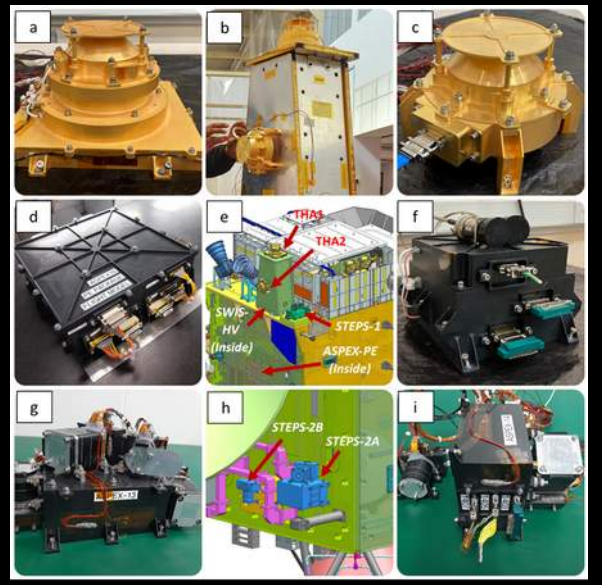
VELC



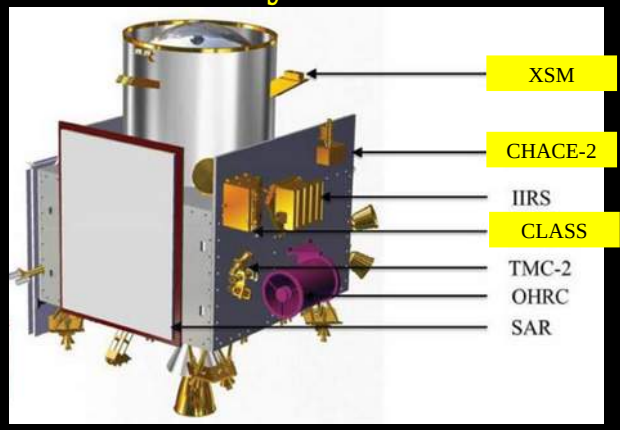
MAG



ASPEX

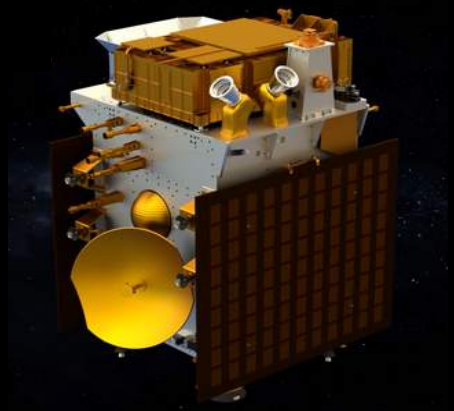


Chandrayaan-2



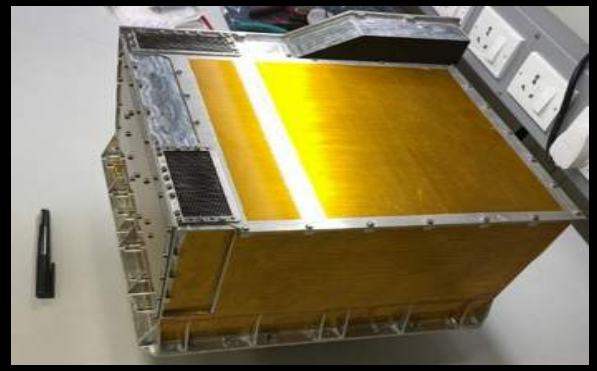
XSPECT Payload on XPoSat - 1Jan 2024 launch

GRASP onboard GSAT-19



Aditya-L1
Space based observatory class solar mission from India at Lagrange point L1
6th Jan 2024 – L1 insertion

PAPA



Heliophysics- Operational Payloads

Geostationary Radiation Spectrometer (GRASP) onboard GSAT-19

Measure differential flux and energy spectrum of electrons, protons and alphas in the energy range:

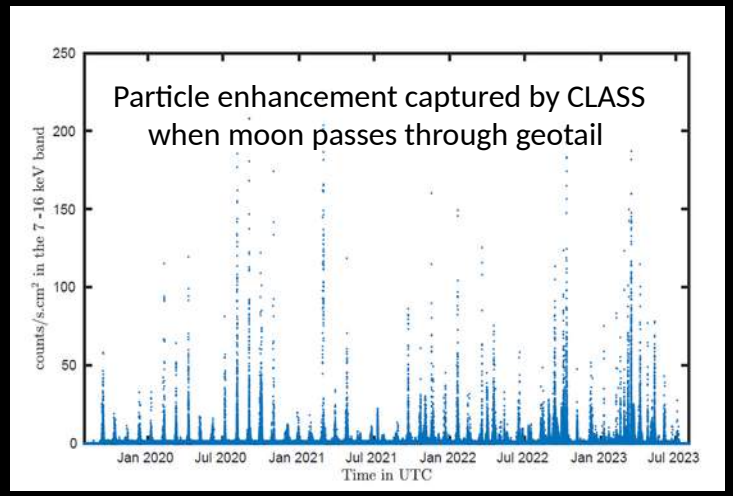
- Electrons : 0.5 – 10 MeV , Protons : 5 – 85 MeV, Alphas : 18 – 85 MeV
- Monitoring of the radiation environment at Geostationary Orbit – 48 deg E.

Data availability: https://pradan.issdc.gov.in/grasp

Chandrayaan-2 Large Area Soft X-ray Spectrometer (CLASS)

- X-ray fluorescence (XRF) experiment on board Chandrayaan-2 Orbiter to map the elemental abundances on the lunar surface.
- The operating energy range 0.8 keV to 15 keV.
- Sensitive to CME,SPE and Geotail particle dynamics.

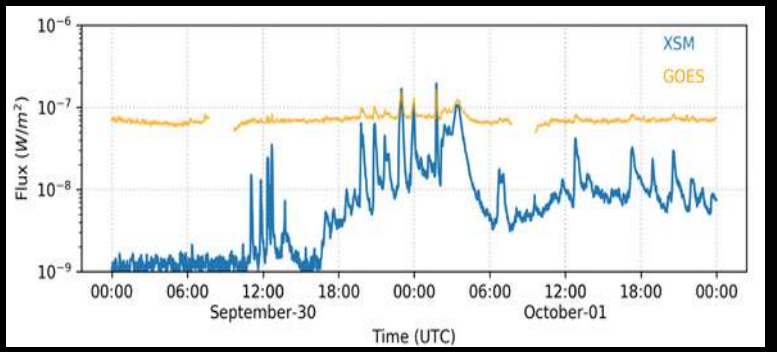
Data availability: https://pradan.issdc.gov.in/ch2



X-ray Solar Monitor (XSM) onboard Chandrayaan-2

- Energy range of 1-15 keV with a spectral resolution of better than 180 eV at 5.9 keV.
- Cover wide range of X-ray intensities
- Currently the best solar X-ray spectrometer operating regularly

Data availability: **https://pradan.issdc.gov.in/ch2**



ADITYA-L1

Type	Payload	Capability
Remote Sensing	Visible Emission Line Coronagraph (VELC)	Corona/ Imaging & Spectroscopy (1.05 – 3Rsun Imaging) & (1.05 to 1.5Rsun Spectroscopy)
	Solar Ultraviolet Imaging Telescope (SUIT)	Photosphere and Chromosphere/ Imaging – Narrow & Broadband (0.7arcsec/pixel)
	Solar Low Energy X-ray Spectrometer (SoLEXS)	Soft X-ray spectrometer (Sun-as-a-star) (1 – 22keV)
	High Energy L1 Orbiting X-ray Spectrometer (HEL1OS)	Hard X-ray spectrometer (Sun-as-a-star) (10 – 200keV)
In-situ	Aditya Solar wind Particle Experiment (ASPEX)	Solar wind/ Particle Analyzer Protons & Heavier Ions with directions (100eV – 20keV) & (20keV/n – 5MeV/n) & H/He
	Plasma Analyser Package For Aditya (PAPA)	Solar wind/ Particle Analyzer Electrons & Heavier Ions with direction (10eV – 3keV) & (10eV to 25keV/n) & H/He + heavy
	Magnetometers	In-situ Magnetic Field (Bx, By, and Bz)

For more details, Aditya-L1 related papers available at: https://al1ssc.aries.res.in/publications; Tropical issue in Solar Physics under review

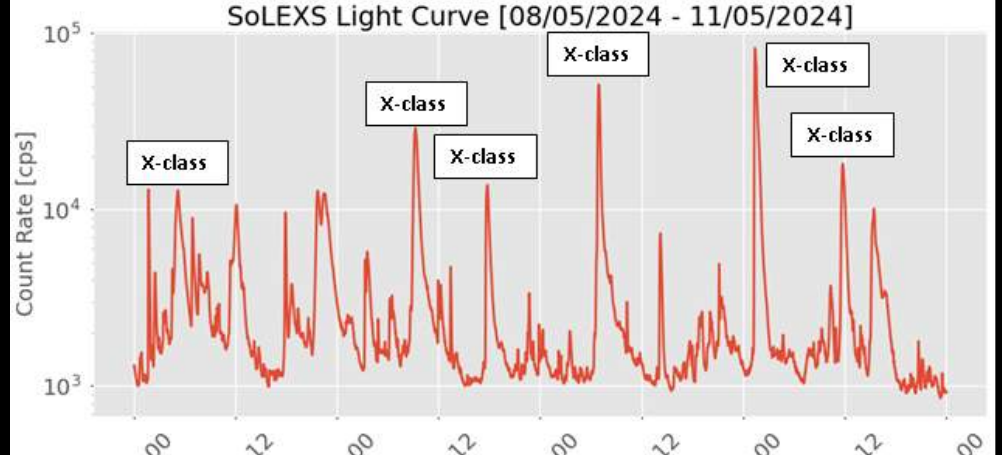
Multi-Observatory Observation – A case

Ground based

Not to scale

BHUVAN , NRSC/ISRO

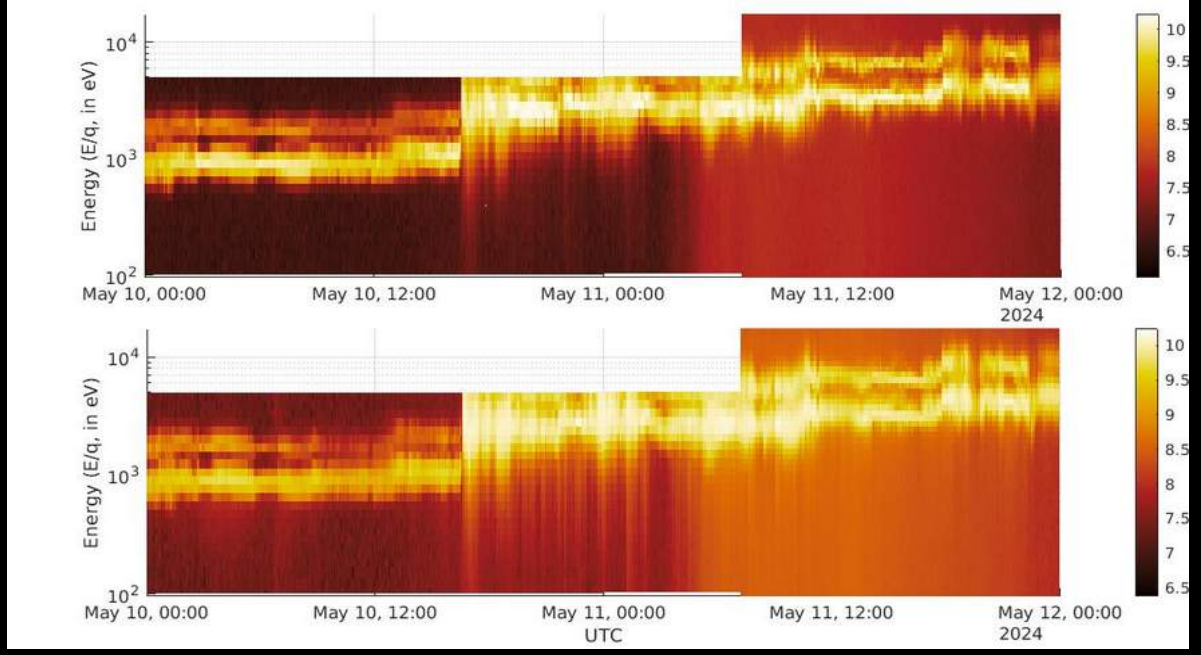
May 2024 Event

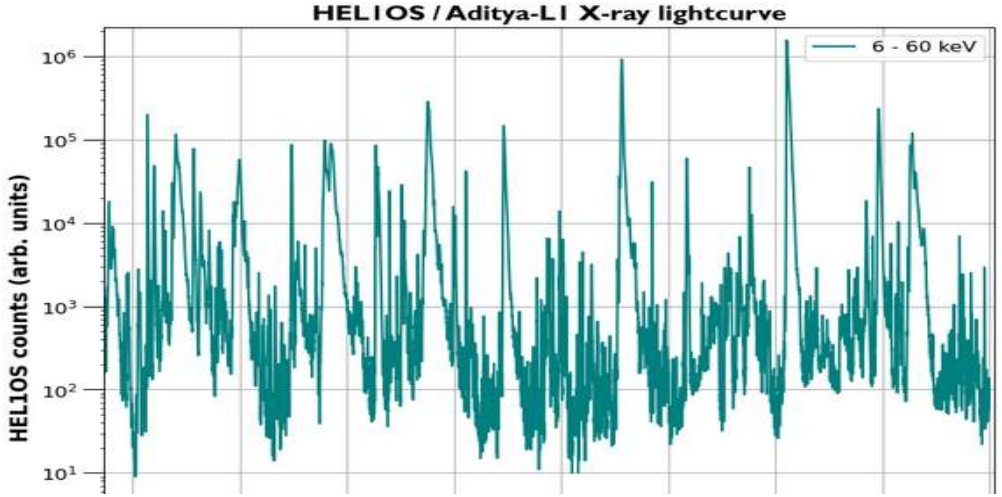


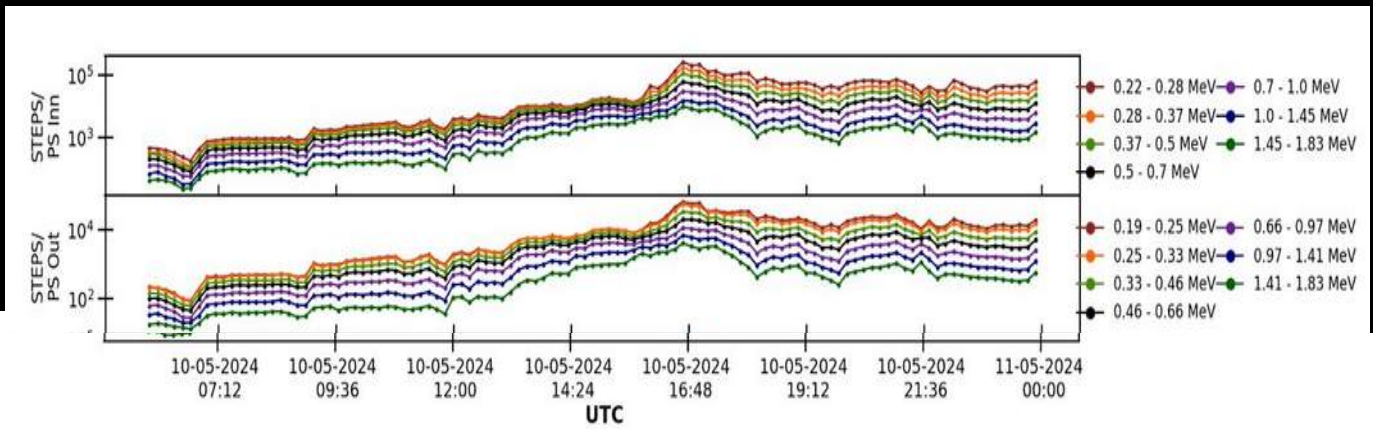
Courtesy: Aditya-L1 Team

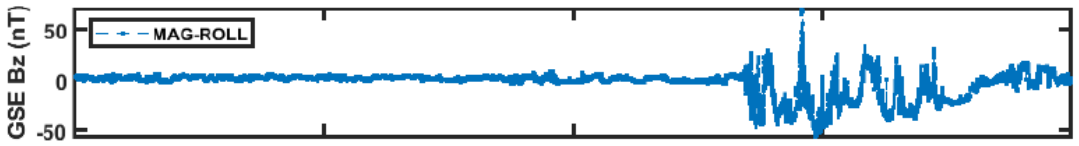
X-ray P/Ls

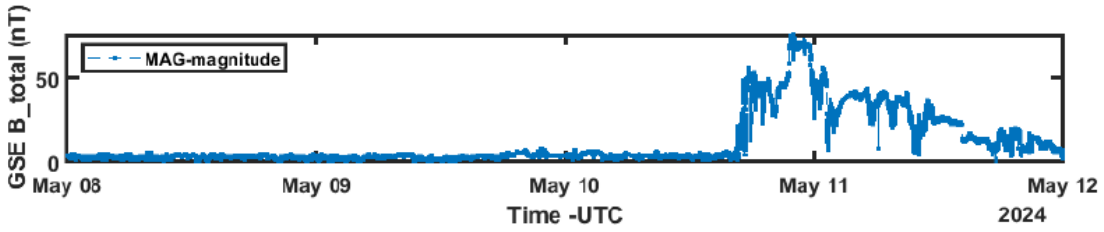
ASPEX







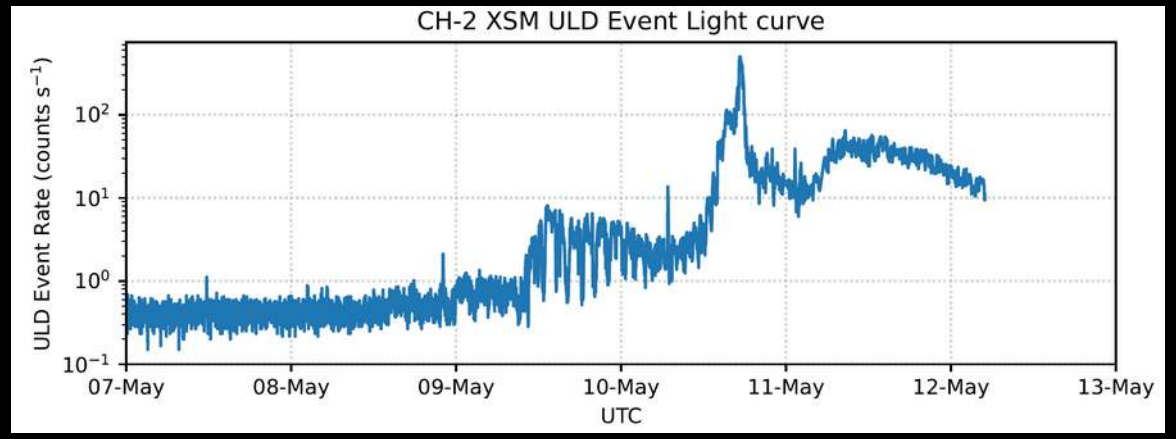




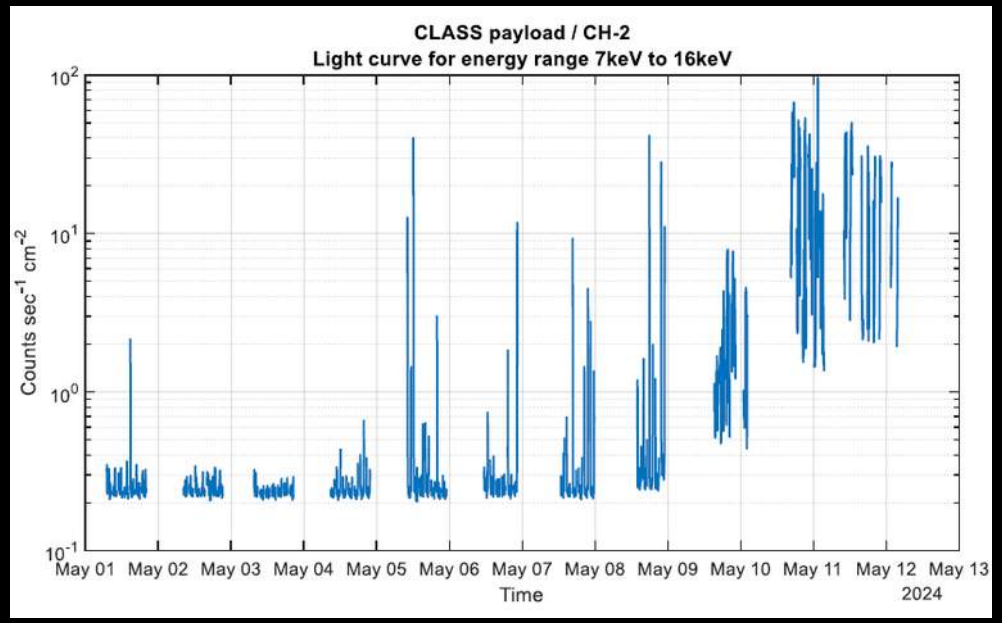
MAG

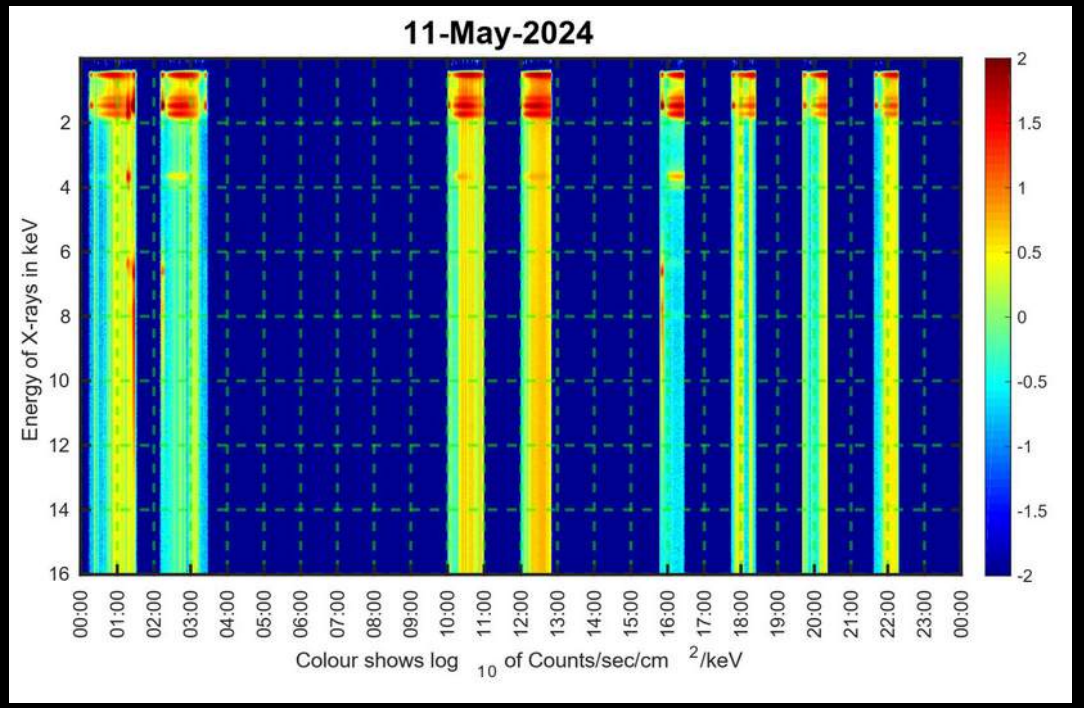
Multi-Observatory Observatio – A case (At L1)

Multi-Observatory Observation – A case (At Lunar)



Variability of high-energy particles in the lunar orbit from ULD events observed by Chandrayaan-2 XSM c (Courtesy: PRL/DOS)



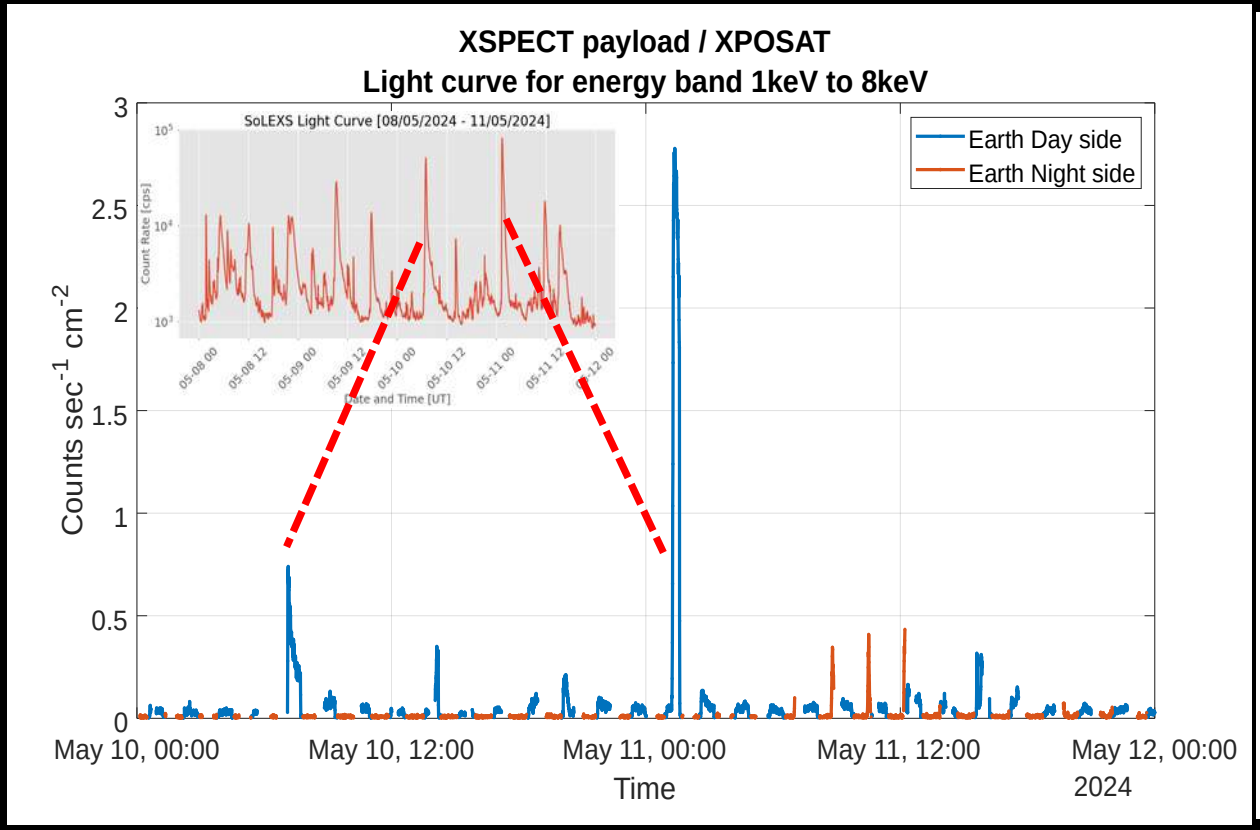


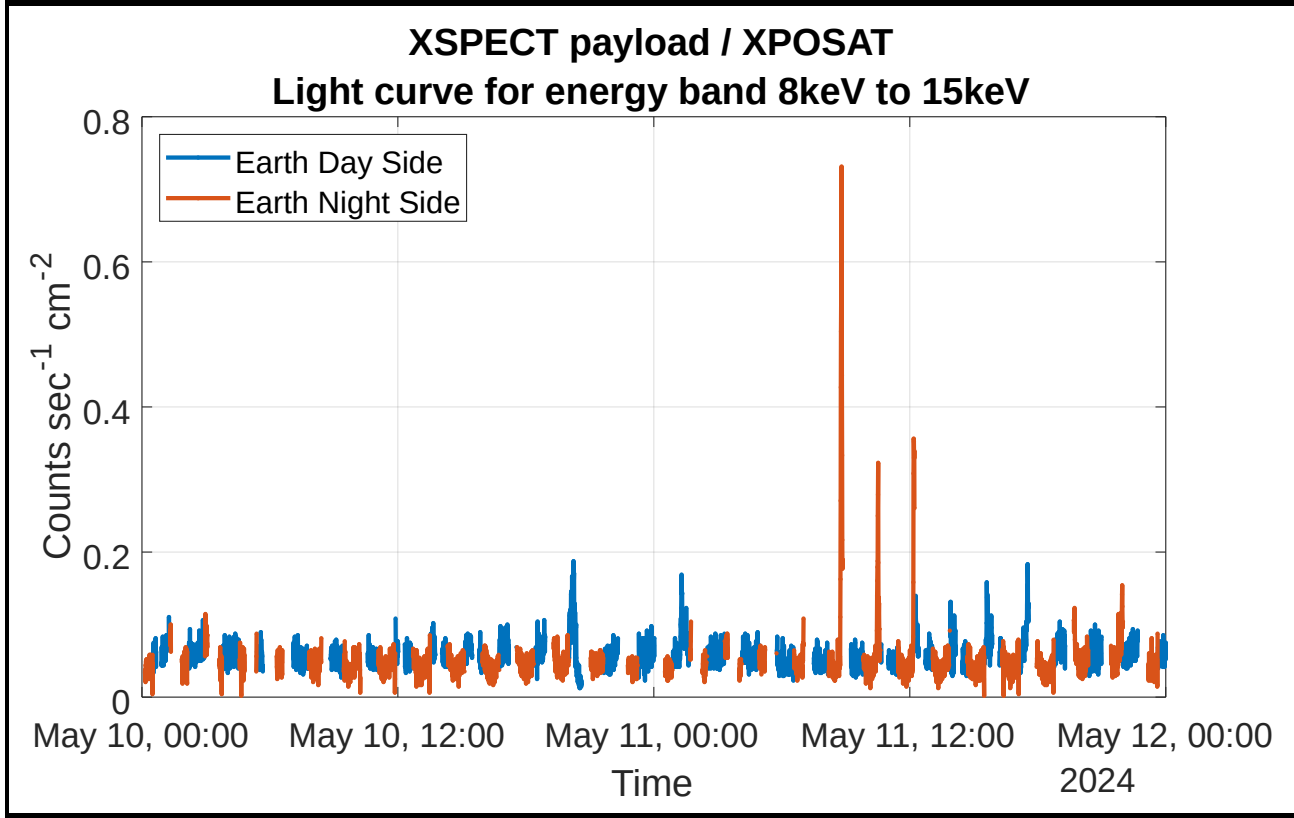
CLASS spectrogram showing lunar X-rays as well as signal due to particles arriving at the Moon related to the high solar activity (courtesy: URSC/ISRO)

The Signal in CLASS in the 7-16 keV energy band arises from particles. The increased rates due to the high solar activity can be seen in the light curve (courtesy: URSC/ISRO).

Multi-Observatory Observation – A case (At LEO)

Courtesy: XSPECT Team



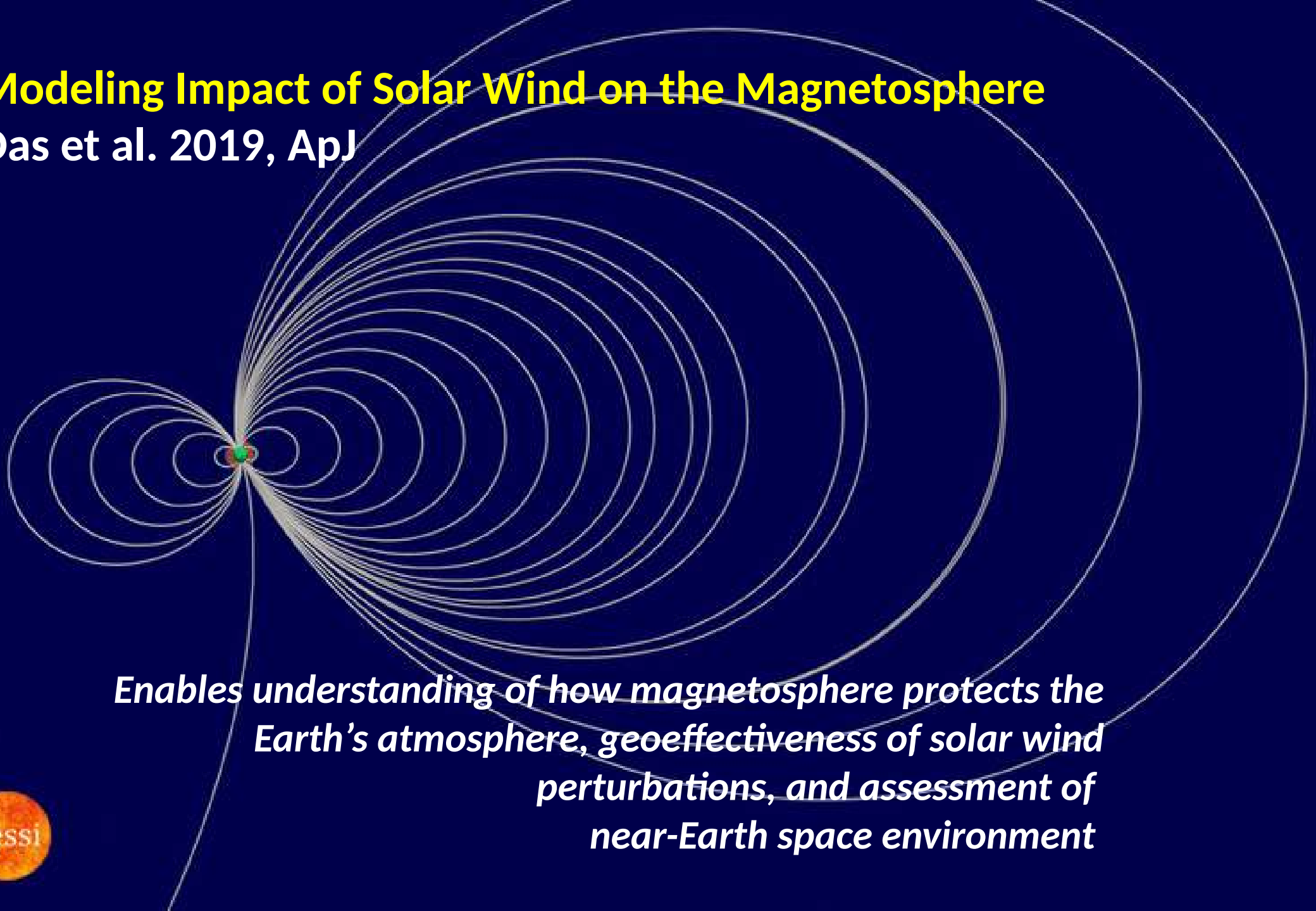


In XSPECT, Energy Band from 1keV to 8 keV is earth scattered solar x-rays. Reflected X-rays from the Solar flares are seen in the day-side as marked in the red dashed line. The inset is the SoLEXS light curve showing the solar flares.

In XSPECT, Energy Band from 8keV to 15 keV is dominantly particle induced counts.

Modeling Impact of Solar Wind on the Magnetosphere

Das et al. 2019, ApJ



Enables understanding of how magnetosphere protects the Earth's atmosphere, geoeffectiveness of solar wind perturbations, and assessment of near-Earth space environment

Courtesy: CESSI

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//CESSI SPACE WEATHER BULLETIN//10 MAY 2024//SUMMARY: CHANCES OF SEVERE GEOMAGNETIC PERTURBATIONS//Several magnetic active regions are currently on the visible solar disk, including a super active region, AR 13664, which has produced multiple high energy flares. AR 13644 continues to be in extreme flare productive state. A series of solar magnetic storms (CMEs) have been launched with at least four of them estimated to be directed towards Earth. Because of chances of storm interactions it is difficult to predict the arrival times of each individual storms. Our estimates suggest the fastest of the CMEs would make Earth-fall on Saturday, 11 May around 03.20 UT with a speed of about 800 km/s with an uncertainty of about 200 km/s. This impact, combined with the expected back-to-back CME hits may generate sustained space weather perturbations resulting in intense and long-lasting geomagnetic storms over 11-12 May. Near-Earth space environment is expected to be hazardous, density perturbations are expected at Leo Earth Orbit, and energetic particle environment is expected to be elevated in the upper atmosphere. Auroras extending to mid-latitudes are also expected.

http://www.cessi.in/spaceweather//

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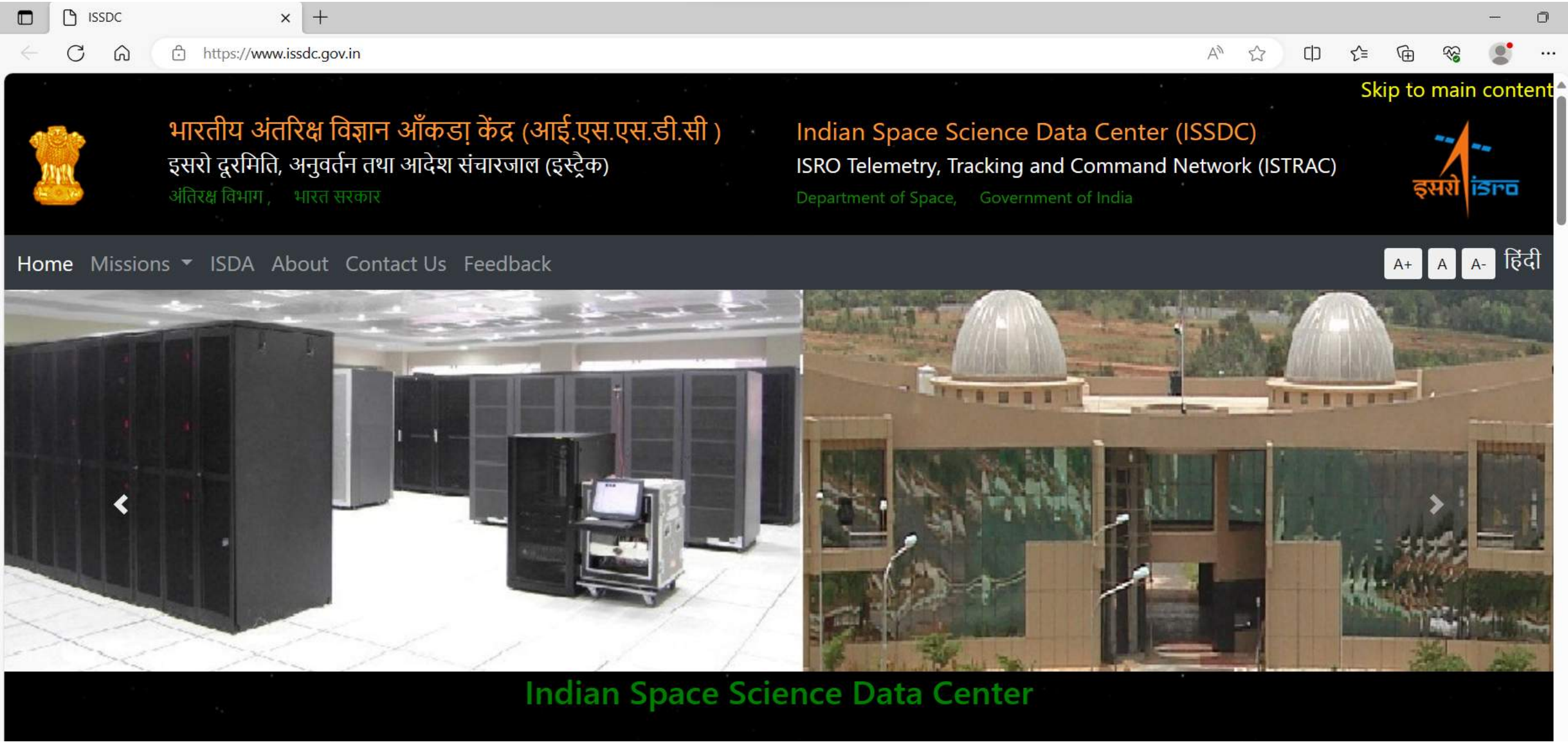
Courtesy: CESSI

Repository of the Space Science Data

Accessible for public use: www. https://www.issdc.gov.in/



Thank you