INTERNATIONAL SPACE SCIENCE INSTITUTE - BEIJING

APSCO

SPACE WEATHER:

FROM SOURCE TO IMPACT IN THE HELIOSPHERE

THE 4th

SPACE SCIENCE SCHOOL

HANDBOOK

NOVEMBER 03-10, 2025

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Editor/Graphic Design: Francesca Garfagnoli, ISSI-BJ

4th APSCO & ISSI-BJ Space Science School

FOREWORDS

On behalf of the Planetary Environmental and Astrobiological Research Laboratory at Sun Yat-sen University, it is my great honor to extend a warm welcome to all participants of the 4th International APSCO & ISS-BJ School, focusing on the timely and compelling theme: "*Space Weather: From Source to Impact in the Heliosphere.*"

Space weather stands at the intersection of fundamental science and critical application—a domain where solar activity reaches across space to influence planetary environment and human technology. Understanding its chain of processes, from solar eruptions to their terrestrial consequences, is not only a scientific challenge but also a necessity for safeguarding modern infrastructure and advancing space exploration.

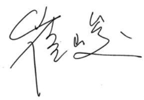
As the host institution, we are deeply committed to fostering an environment where young scientists can thrive. Through a combination of expert lectures, hands-on training, and collaborative projects, this School offers a unique opportunity to deepen your knowledge, sharpen your research skills, and join a global network of peers and pioneers.

In recent years, our laboratory has been actively engaged in planetary science research, including solar activity and solar wind dynamics, physical/chemical processes in the space-atmosphere-surface-interior environments of solar system objects, and the detection and modeling of exoplanets. We are proud to support this School as part of our ongoing commitment to space science education and international collaboration.

I would like to express my sincere gratitude to APSCO and ISSI-BJ for their visionary partnership, and to all the lecturers, tutors, and staff whose dedication has made this event possible. My special thanks also go to the participants—your curiosity and passion are the very forces that drive our field forward.

I wish you all a stimulating, productive, and unforgettable experience here in Zhuhai. May this School inspire you to pursue new frontiers in space science and contribute to a deeper understanding of our Sun-Planet connection.

Jun Cui



Head of Planetary Environmental and Astrobiological Research Laboratory

Sun Yat-sen University

I am very pleased to share my heartfelt thoughts on the upcoming 4th APSCO & ISSI-BJ Space Science School, themed "*Space Weather: From Source to Impact in the Heliosphere*." This event, co-organized by APSCO and ISSI-BJ, will bring together young researchers, Master's and Ph.D. students, post-doctoral fellows, and early-career scientists from APSCO Member States and beyond. It serves as a unique platform to advance professional knowledge, foster international cooperation, and inspire the next generation of space scientists and engineers.

Space weather is not only a frontier of scientific exploration but also a field with direct implications for our daily lives. Its effects—from solar activity to impacts on Earth's atmosphere and technological systems—remind us of the importance of global collaboration and continuous innovation. By tracing the full chain of space weather phenomena, participants will gain valuable insights into both fundamental theories and real-world applications. The lectures, practical sessions, and group projects designed for this School will help participants enhance their academic expertise while cultivating teamwork and problem-solving skills that are vital for addressing future challenges.

In recent years, APSCO and its Member States have made remarkable progress in space science cooperation. Highlights include the successful launch of Pakistan's lunar mission *iCube-Q*, the *Practice-19* space breeding experiment, and the *Space Science Data Sharing and Application Project* completed last year, which significantly advanced collaborative research among members. Looking ahead, APSCO will continue to promote ambitious initiatives in lunar exploration, ionospheric studies, earthquake-related research, and other space science projects, building a stronger foundation for regional and global scientific development. These achievements and plans not only demonstrate the vitality of regional cooperation but also provide meaningful context for the themes and discussions of this School.

None of these achievements would have been possible without the dedication and collaboration of many individuals and institutions. On behalf of APSCO, I would like to first thank my colleagues whose hard work and careful preparation have laid a solid foundation for this event and for our broader cooperative efforts. I also extend my sincere gratitude to ISSI-BJ for their strong support and close partnership, to Sun Yat-sen University for graciously hosting the School, and to all lecturers, tutors, and organizers for their tireless efforts. It is through the combined contributions of all parties that this School will become a truly meaningful and inspiring experience.

I look forward to witnessing the fruitful exchanges and collaborations that will emerge from this program, and I wish every participant a rewarding, inspiring, and memorable journey of discovery.

Yansong Xu

Director-General of Education and Training Department
Asia-Pacific Space Cooperation Organization (APSCO)

4th APSCO & ISSI-BJ Space Science School

It is my great privilege to address you as you are preparing to immerse yourselves in the fourth ISSI–Beijing/APSCO Space Science School on "Space Weather: From Source to Impact in the Heliosphere". Our biennial joint Space Science Schools are now an established fixture of ISSI–Beijing programming. They have become highly valued by all involved—ISSI–Beijing, APSCO, our expert lecturers and, thankfully, all participants. This year, we are particularly pleased to have secured the invaluable support of our colleagues at Sun Yat-sen University (SUSY) as our hosts. Thank you!

Our lead scientist, Professor Robertus von Fay-Siebenburgen, has managed to put together an excellent scientific programme, staffed by internationally leading lecturers in their diverse disciplines. You will dive into the depths of the physics generating solar activity, the solar wind and its impact on the Earth's environment—both from physics and societal perspectives. These Space Science Schools are particularly valuable in bringing together participants from a wide range of backgrounds. Whereas scientists at ISSI–Beijing tend to focus on the basic, underlying science, APSCO participants often hail from an engineering background. I encourage you to take full advantage of the interesting and productive synergies that can emerge when combining such diverse expertise.

Don't forget that these meetings are also important stepping stones to establishing lifelong friendships and collaborations. Outside of your dedication to solar physics, space weather or even space engineering, make sure to get to know the other participants in an informal setting. After all, the young scientists and engineers of today will be the scientific leaders of tomorrow, and having extended international networks of colleagues, friends and acquaintances will make those developments (and, likely, your career progression) just that little bit easier.

To conclude, I wish you a great Space Science School! I would be remiss if I didn't acknowledge those colleagues who have made this fourth School a reality, including the ISSI–Beijing staff (particularly Ms Francesca Garfagnoli), our friends at APSCO (notably, Ms Charis Xiong) and our colleagues at SUSY (not least Professor Jun Cui and Dr. Yutian Cao)—as well as our sponsors (including APSCO, the National Space Science Center, the Chinese Academy of Sciences and SUSY) who have generously supported the School's organisation. Thank you to all!

With my best wishes,
Richard de Grijs

Executive Director
International Space Science Institute-Beijing (ISSI-BJ)

Dear School Participants!

It is my great pleasure to welcome you to the 4th APSCO & ISSI-BJ Space Science School on "*Space Weather: From Source to Impact in the Heliosphere*", to be held at Sun Yat-sen University in Zhuhai, China, from November 3 to 10, 2025.

I'm a professor at the University of Sheffield (United Kingdom), and one of the organisers of this fantastic international school. The idea was born when we had another science meeting, supported by ISSI-BJ, earlier this year in Beijing. I became very enthusiastic about the opportunity, given its timeliness and high importance in the cross-field of solar and heliosphere physics. Unfortunately, I cannot be present myself in person, because on the same week I'll have to participate a ceremony in London, where I will be given the 2025 Cecilia Payne-Gaposchkin Medal and Prize. I hope, you all will forgive me for not being there with you sharing the wonderful milieu at the beautiful city of Zhuhai and will accept my humble excuse.

Space weather (often abbreviated as SWx in the scientific literature) is one of the highly emerging and very important area of space physics. Among the many sub-disciplines, it deals with investigating the source, eruption, propagation, and impact of solar storms with the Earth.

These storms, that are the largest explosions in the entire Solar System, may realise in the form of solar flares or Coronal Mass Ejections (CMEs). It is vital for humanity that we understand the processes going on behind of these rather volatile manifestations of Nature because of their potentially devastating impact they may have on our tech-driven modern civilisation. It is not anymore a question of "whether" but when a major solar eruption may happen that poses a considerable risk to out technosphere.

The main theme of the School is to address a wide range of the underlying physical processes from the Sun, through the solar wind, interplanetary space and the Earth's magnetosphere, ionosphere and thermosphere. You will be introduced by some of the best and finest international experts of these exciting and occasionally rather complex topics through a series of lectures followed by hand-on projects.

It is also important that you meet your fellow future scientists in a friendly and encouraging environment. Use all the occasions given to socialize and allow yourselves to immerse into the fantastic opportunities provided by the traditionally highly welcoming Chinese culture.

I wish you good luck and great success at the School and hope to see you many of you as young scientists in the near future!

Best wishes,
Robert (Erdelyi) von Fay-Siebenburgen

Head of Solar Physics and Space Plasma Research Centre

The University of Sheffield

ORGANIZERS & SPONSORS

International Space Science Institute-Beijing

The International Space Science Institute in Beijing (ISSI-BJ) was jointly established by the National Space Science Center (NSSC) and the International Space Science Institute (ISSI) with the support of the International Cooperation Bureau and the Space Science Strategic Project of the Chinese Academy of Sciences (CAS). ISSI-BJ is a close cooperation partner of ISSI in Bern. The two institutes share the same Scientific Program Committee, the same study tools, and other information of mutual relevance and interest. However, both use independent operational methods and different funding sources. Its primary mission is to provide an international platform for scientists to foster collaborative research in space sciences, from strophysics to solar-terrestrial physics.

ISSI-BJ is a non-profit research institute. Our main mission is to contribute to the achievement of a deeper scientific and technological understanding of future space missions as well as of the scientific results from current and past missions through multidisciplinary research, possibly involving ground based observations, modelling, numerical simulation and laboratory experiments. We offer generous financial support to the scientists that come to Beijing: we offer coffee breaks, snacks, lunches and a social dinner at our institute, as well as travel and hotel expenses for the conveners of Workshops and Forums, and the leaders of the International Teams. After each meeting, we also offer support for publishing and promoting articles, essays and peer-reviewed papers.

Asia-Pacific Space Cooperation Organization

The Asia-Pacific Space Cooperation Organization (APSCO) was formally inaugurated in 2008 with the objective of **peaceful uses of space by developing space applications, exploiting space technology and exploring space science for promotion of sustainable social-economic development** and benefit of people in the Asia-Pacific region.
APSCO actively and continuously implements the collaborative activities following the organizational objectives and incorporating the interests and demands of all APSCO Member States. APSCO developed its mid-to-long term strategic implementation plan and implemented a number of engineering and joint research projects, thereby enhancing collective capabilities. APSCO regularly conducted the degree education and training programs, organized international symposiums and space law forums/workshops periodically, which laid the solid technical foundation of the future development of the organization and gathered rich experience of multilateral cooperation for resources sharing upon those efforts. With accumulated knowledge and experiences, APSCO is now developing smoothly. In order to bring the common prosperity in the Asia-Pacific Region, APSCO will focus on the integration of current resources, infrastructures and program results to establish operational service networks such as education, data sharing, space technology application, disaster monitoring, and even satellite constellation and ground stations. As an inter-governmental space cooperation organization, APSCO has already developed **eight full Member States** namely Bangladesh, China, Iran, Mongolia, Pakistan, Peru, Thailand, Türkiye, one Signatory State Indonesia, One Associate Member Egypt and one Observer State Mexico. APSCO is open to all the counties in Asia-Pacific region and even countries outside this region could join as associate members. It is believed that by pooling the resources of space activities and allowing more Member States to join the APSCO family, we can use and share them more efficiently.

SCHOOL OUTLINE & PROGRAM

About the School

Participants will gain in-depth expertise in the science of space weather, related observational methods, and applications throughout the heliosphere. While space weather phenomena span the entire Sun–Earth system and the Heliosphere, this School will specifically address the full chain of space weather effects from its solar origins to terrestrial impacts and magnetospheric dynamics (including solar wind interactions), ionospheric and the upper atmospheric processes. Through interdisciplinary lectures and practical sessions, participants will explore these interconnected domains, with emphasis on both fundamental science and operational applications.

Structure of the School

The School will commence with three days of introductory lectures delivered by invited experts in the field of Space Weather. These sessions will provide a comprehensive overview of key topics, with each lecture followed by dedicated time for in-depth discussion and questions from participants. Our speakers are distinguished scientists and engineers, selected for their expertise, teaching excellence, and experience in mentoring early-career researchers.

Equipment

English will be the official working language for all school activities, including lectures, working group sessions, and presentations. Participants are required to bring their own laptop computers equipped with standard office software.

Publications & Website

All lecture presentations delivered during the School will be compiled in digital format and made available to registered participants through a dedicated section of the School's official website. This curated collection will serve as a valuable reference resource for attendees. The collaborative research results developed by the Working Groups will be published as a comprehensive final report in a special edition of our *Taikong* magazine.

Working Groups Outline

Participants will be divided into four thematic Working Groups aligned with their academic backgrounds. Under the guidance of expert tutors, each Group will develop a collaborative research project focused on key aspects of space weather. These projects will result in comprehensive reports, to be published in a dedicated issue of ISSI-BJ's Taikong magazine, highlighting the School's scientific outputs. The programme will culminate on the final day with research presentations from each Working Group. These sessions will serve as an opportunity for participants to showcase their achievements while receiving constructive feedback and recommendations from both tutors and their peers.

Working Group	Research Topics
Solar Activity (Local & Global Scales)	Examining the solar drivers of space weather, from flare processes to coronal mass ejections.
Investigating Martian X-ray Radiation Properties & Their Relationship to Solar Irradiance	Exploring the solar–terrestrial interactions and their role in space weather.
Ionosphere & Upper Atmosphere	Investigating how solar and geomagnetic activity influence the Earth's near-space environment.
Space Weather – From Physical Mechanisms to Data-Driven	Tracing the chain of effects from solar eruptions to ground-level technologies.

1. Solar Activity (Local & Global Scales)

Tutors: Zhenjun Zhou

Outline

This topic focuses on the structure and dynamics of the solar atmosphere, with particular emphasis on multiview observations for three-dimensional reconstruction and parameterization of solar filaments, providing insights into their morphology and evolution. These approaches are complemented by nonlinear force-free field extrapolation and visualization, which connect coronal magnetic fields with lower atmospheric structures. Building on this foundation, the topic further introduces the analysis of eruptive flux ropes (ICMEs), focusing on their axial orientation, internal magnetic-field configuration, and links to large-scale eruptive activity. By integrating these perspectives, the topic equips students with essential observational, analytical, and modeling skills, fostering a comprehensive understanding of the three-dimensional nature of the solar atmosphere and its role in driving space weather.

Main Topics

- Multi-view 3D reconstruction and parameterization of solar filaments;
- Nonlinear force-free field extrapolation and visualization of solar magnetic fields;
- Structural analysis of eruptive flux ropes, including axial orientation and internal magnetic-field configuration.

Computer/Software Requirements

It is highly desirable that students bring their laptops with pre-installed ParaView, IDL, SolarSoftWare (SSW), Shell environment (e.g., Bash/Zsh), and Python (≥3.9). These tools will be used throughout the school for 3D visualization, solar image analysis, data handling, and magnetic-field modeling. The system can run on Windows, Mac, or Linux.

• ParaView (recommended version ≥ 5.12): https://www.paraview.org/download/

• IDL (recommended version ≥ 8.7): https://www.nv5geospatialsoftware.com/Product-Downloads/moduleId/19311/viewOrder/previous/controller/Item/action/Index

- SolarSoftWare (SSW): https://sohowww.nascom.nasa.gov/solarsoft/
- Python (≥3.9): https://www.python.org/downloads/
- Shell (Bash/Zsh, included in Linux/Mac, Windows users may install Git Bash): https://gitforwindows.org/

We strongly recommend installing these software environments in advance to ensure smooth participation in hands-on sessions and practical exercises.

Recommended Literature

Thompson, W. T. (2009). 3D triangulation of a Sun-grazing comet. Icarus, 200(2), 351-357.

Zhou, Z., Jiang, C., Song, H., Wang, Y., Hao, Y., & Cui, J. (2023). Quantification of the writhe number of the evolution of solar filament axes. The Astrophysical Journal, 944(2), 175.

Zhou, Z., Zhang, J., Wang, Y., Liu, R., & Chintzoglou, G. (2017). Toward understanding the 3D structure and evolution of magnetic flux ropes in an extremely long duration eruptive flare. The Astrophysical Journal, 851(2), 133.

Berger, M. A., & Prior, C. (2006). The writhe of open and closed curves. Journal of Physics A: Mathematical and General, 39(26), 8321.

Prior, C. B., & Neukirch, S. (2016). The extended polar writhe: a tool for open curves mechanics. Journal of Physics A: Mathematical and Theoretical, 49(21), 215201.

Wiegelmann, T. (2008). Nonlinear force-free modeling of the solar coronal magnetic field. Journal of Geophysical Research: Space Physics, 113(A3).

Wang, Y., Zhou, Z., Shen, C., Liu, R., & Wang, S. (2015). Investigating plasma motion of magnetic clouds at 1 AU through a velocity-modified cylindrical force-free flux rope model. Journal of Geophysical Research: Space Physics, 120(3), 1543-1565.

Wang, Y., Zhuang, B., Hu, Q., Liu, R., Shen, C., & Chi, Y. (2016). On the twists of interplanetary magnetic flux ropes observed at 1 AU. Journal of Geophysical Research: Space Physics, 121(10), 9316-9339.

2. Investigating Martian X-ray Radiation Properties & Their Relationship to Solar Irradiance

Tutors: Sun Tianran

Outline

The Martian environment, lacking a global dipole magnetic field, is directly exposed to the stream of charged particles from the Sun, known as the solar wind. When the solar wind interacts with the Martian atmosphere and exosphere, it can generate X-rays through a process called Charge Exchange. Additionally, solar X-rays (irradiance) can fluorescence off atoms in the Martian upper atmosphere. These X-ray emissions form a global “aura” around Mars, serving as a unique diagnostic tool for understanding the planet’s interaction with its space environment.

The recently launched Chinese satellite, Einstein Probe (EP), with its high-sensitivity Wide-field X-ray Telescope, provides an unprecedented opportunity to study these phenomena. This working group will leverage EP’s cutting-edge data to explore how Martian X-ray emissions are driven by solar activity, a key to unraveling the real-time dynamics of the Martian space weather system.

Main Topics

- **Data Mastery & Signal Extraction**
  1. To become familiar with the data format and calibration of the Einstein Probe.
  2. To identify, extract, and quantify the X-ray signal from the Martian disk and its exosphere from EP observations.
- **Temporal Correlation & Delay Analysis**
  1. To investigate the correlation between the intensity of Martian X-ray flux and concurrent measurements of Solar X-ray Irradiance.
  2. To search for and quantify potential time lags between a solar flare event and the response in Martian X-ray emission. What does this lag tell us about the physical processes involved?
- **Spatial Distribution Mapping**
  1. To map the spatial distribution of X-ray emissions around Mars. Does it appear uniform, or are there bright spots or asymmetries?
  2. To relate the observed spatial patterns to possible drivers, such as the direction of the incoming solar wind or the local Martian crustal magnetic fields.

Expected Outcomes

- Gained hands-on experience with state-of-the-art space telescope data.
- Produced a preliminary analysis of the correlation and time lag between solar irradiance and Martian X-rays.
- Generated a map of the spatial distribution of X-rays around Mars.
- Delivered a collaborative presentation on their findings, forming the basis for a potential future scientific publication.

Recommended Literature

Dennerl., K., X-rays from Mars. Space Science Reviews (2006) 126: 403—433, DOI: 1O.1007/s11214-006-9028 -7

Dennerl., K., C. M. Lisse, A. Bhardwaj, et al., First observation of Mars with XMM-Newton: High resolution X-ray spectroscopy with RGS. A&A (2006) 451, 709–722, DOI: 10.1051/0004-6361:20054253

Cheng., H., C. Zhang, Z. Ling, et al., Ground calibration result of the wide-field X-ray telescope (WXT) onboard the Einstein probe. Experimental Astronomy (2025) 60:15, https://doi.org/10.1007/s10686-025-10025-9

3. Ionosphere & Upper Atmosphere

Tutors: Xin Wan

Outline

The upper atmosphere and ionosphere (60–1000 km) form a dynamic interface linking Earth's neutral atmosphere to interplanetary space, shaped by solar-terrestrial interactions. Their variability is driven by solar radiation, geomagnetic activity, and atmospheric waves, with plasma-neutral interactions governing phenomena like ionospheric density perturbations and scintillation. Scientifically, studying this region unravels multi-scale Earth-system coupling (e.g., lower atmospheric waves modulating ionospheric irregularities) and advances plasma physics and space weather model benchmarking. Technologically, it is critical for mitigating impacts on GPS/GNSS navigation, satellite communications, low-Earth orbit satellite drag, and geomagnetically induced currents (GICs) threatening power grids. Thus, this research area bridges solar-heliospheric processes to terrestrial societal and infrastructure risks. The working group aims to to focus on the lowlatitude ionospheric dynamic of intermediate-to-small scale (e.g., ionospheric irregularities), to understand the coupling process across different scales and evaluate the space weather effects.

Main Topics

- Spaceborne and ground-based observations of ionospheric irregularities;
- Scintillation indexes.

Main Task

Compare the climatologies of spread F, scintillation, ionospheric irregulatities, explore the mechanisms of their similarities, difference. Additionally, if possible, search and explain the deviation of their behaviour during space weather events.

Data

- Madrigal data service (http://madrigal.haystack.mit.edu/madrigal/)
- Digisonde data from DIDBase at the Global Ionosphere Radio observatory (http://giro.uml.edu) (Questions: I. Galkin)
- Swarm data from the Swarm data center at ESA at https://earth.esa.int/web/guest/swarm/data-access
- IGS-TEC data from NASA CDDIS archive at https://cddis.nasa.gov/Data_and_Derived_Products
- IGS-TEC data and movie display from NASA CDAWeb at https://cdaweb.gsfc.nasa.gov/ (Questions: D. Bilitza)
- COSMIC F-peak and topside electron densities for the COSMIC data center at http://cdaac-www.cosmic.ucar.edu/cdaac/products.html

Recommended Literature

Aa, E., Huang, W., Liu, S., Ridley, A., Zou, S., Shi, L., et al. (2018). Midlatitude plasma bubbles over China and adjacent areas during a magnetic storm on 8 September 2017. Space Weather, 16(3), 321–331. https://doi.org/10.1002/2017SW001776

Abdu, M. A. (2012). Equatorial spread F/plasma bubble irregularities under storm time disturbance electric fields. Journal of Atmospheric and Solar - Terrestrial Physics, 75–76, 44–56.

Burke, W. J., Huang, C. Y., Gentile, L. C., & Bauer, L. (2004). Seasonal-longitudinal variability of equatorial plasma bubble occurrence. Annales Geophysicae, 22(9), 3089–3098. https://doi.org/10.5194/angeo-22-3089-2004

Huang, C.-S., & Hairston, M. R. (2015). The postsunset vertical plasma drift and its effects on the generation of equatorial plasma bubbles observed by the C/NOFS satellite. Journal of Geophysical Research: Space Physics, 120, 2263–2275. https://doi.org/10.1002/2014JA020735

Su, S.-Y., Chao, C. K., & Liu, C. H. (2008). On monthly/seasonal/longitudinal variations of equatorial irregularity occurrences and their relationship with the postsunset vertical drift velocities. Journal of Geophysical Research, 113, A05307. https://doi.org/10.1029/2007JA012809

Wan, X., Xiong, C., Rodriguez-Zuluaga, J., Kervalishvili, G. N., Stolle, C., & Wang, H. (2018). Climatology of the occurrence rate and amplitudes of local time distinguished equatorial plasma depletions observed by Swarm satellite. Journal of Geophysical Research: Space Physics, 123, 3014–3026. https://doi.org/10.1002/2017JA025072

Xiong, C., Stolle, C., & Lühr, H. (2016). The Swarm satellite loss of GPS signal and its relation to ionospheric plasma irregularities. Space Weather, 14(8), 563–577. https://doi.org/10.1002/2016SW001439

4. Space Weather – From Physical Mechanisms to Data-Driven

Tutors: Yudong Ye

Outline

Space weather originates from solar eruptions such as flares, coronal mass ejections (CMEs), and high-speed solar wind streams, which interact with Earth's magnetosphere and ionosphere. These interactions drive geomagnetic storms and auroras and can affect satellites, navigation, and power systems. Understanding the underlying physical processes is crucial, but accurate forecasting also requires effective use of observations and data analysis.

This working group aims to provide students with an integrated perspective: (1) the fundamental physical mechanisms of solar wind–magnetosphere coupling, and (2) modern data-driven approaches, including machine learning, for predicting geomagnetic disturbances. Students will gain both conceptual understanding and hands-on experience analyzing real space weather data.

Main Topics

- Solar drivers of space weather: flares, CMEs, and high-speed streams.
- Solar wind–magnetosphere–ionosphere coupling and the development of geomagnetic storms.
- Geomagnetic indices (Dst, SYM-H, Kp, etc.) as measures of magnetospheric activity.
- Forecasting approaches: persistence, empirical formulas, and machine learning models.
- Interpretable ML: identifying physical drivers from data.

Main Task

- Identify a geomagnetic storm event using solar wind and Dst index data.
- Interpret storm phases (initial, main, recovery) in connection with solar wind structures.
- Compare persistence and simple forecast models of geomagnetic activity.
- Explore feature importance to see which solar wind parameters dominate storm-time prediction.
- Discuss strengths and limitations of combining physics-based and ML-based approaches.

Data

Solar wind and IMF data from the OMNI database (magnetic field, velocity, density, dynamic pressure, etc.), together with geomagnetic indices (Dst, SYM-H, Kp, etc.). Pre-prepared Jupyter notebooks and case studies of major storm events will be provided for hands-on analysis.

Computer/Software Requirements

Participants are expected to bring their own laptops for the hands-on sessions. The following software and tools are recommended:

1. **Python (≥3.8)** – Installed with scientific libraries such as numpy, pandas, matplotlib, and scikit-learn. These will be used for data handling, visualization, and basic machine-learning exercises.
2. **Jupyter Notebook / JupyterLab** – For running the provided tutorials and interactive analysis.

3. **Anaconda or Miniconda (recommended)** – To simplify package management and ensure a consistent Python environment.
4. **Text Editor / IDE** – Such as VS Code, Spyder, or PyCharm, for those who prefer script-based workflows.
5. **Internet Access** – Required for downloading datasets (OMNI solar wind and geomagnetic indices) and for accessing shared course materials.
Pre-prepared Jupyter notebooks, along with selected case study data, will be distributed before the course to ensure all participants can follow the exercises without additional setup.

Recommended Literature

Top 3 Starter Readings

1. Pulkkinen, T. (2007). *Space weather: Terrestrial perspective*. Living Reviews in Solar Physics, 4(1), 1.
– Clear and accessible review of the basics of space weather.
2. Bothmer, V., & Daglis, I. A. (2007). *Space Weather: Physics and Effects*. Springer. (Chapters 1–3)
– A good textbook-style introduction covering the Sun, solar wind, and Earth's space environment.
3. Eastwood, J. P., et al. (2017). *The scientific foundations of forecasting space weather*. Space Science Reviews, 212(3-4), 1221-1252.
– A short and modern review that introduces the challenges and methods of prediction.

Review Articles & Forecasting Approaches

• Gombosi, T. I., et al. (2018). *Living with space weather: Predicting the Sun–Earth system*. Space Science Reviews, 214, 56.
– A broad review of forecasting models and services.
• Camporeale, E. (2019). T**he challenge of machine learning in space weather: Nowcasting and forecasting**. Space Weather, 17, 1166–1207.
– A key review bridging space weather and data science.

Selected Applications in ML

• Ye, Y., Liu, J., Hao, Y., Cui, J. (2024). *Evaluating the Geoeffectiveness of Interplanetary Coronal Mass Ejections: Insights from a Support Vector Machine Approach with SHAP Value Analysis*. Astrophysical Journal, 972, 52.
– A clear example of using interpretable ML (SVM + SHAP) to identify physical drivers of geomagnetic activity.

- Liu, J., Ye, Y., Shen, C., et al. (2018). *CAT-PUMA: A New Tool for CME Arrival Time Prediction using Machine Learning Algorithms*. Astrophysical Journal, 855, 109.
  – An early example of applying ML for CME arrival prediction.

For Students Interested in General ML Foundations

- Géron, A. (2019). *Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow*. O'Reilly.
  – Practical Python-based ML introduction.

Practical Data Resources

- NASA OMNI Database: https://omniweb.gsfc.nasa.gov/
- NOAA Space Weather Prediction Center: https://www.swpc.noaa.gov/

About the Organizers

Charis Xiong

E&T Manager of Education and Training Department

ASIA-PACIFIC SPACE COOPERATION ORGNIZATION (APSCO)

As one of the local staff members working in APSCO Secretariat for many years, it's my fourth time organizing a Space Science School. It is incredibly rewarding to witness this initiative evolve year after year and to see the passion for space science ignite in a new generation of students. I consider it a true privilege to play a part in inspiring the bright minds who will shape the future of space exploration.

Francesca Garfagnoli

PR & Editorial Manager

International Space Science Institute-Beijing

I cherish this opportunity to organize a Space Science School in Zhuhai. We will try our best to provide you with a platform for discussing and learning space weather-related knowledge. I hope that you'll be able to take as much as possible from the lectures and put that knowledge into practice during the Working Groups. I also hope that you'll try to make as many connections as you can, as these could prove invaluable for your future.

Yutian Cao

Associate Professor

Planetary Environmental and Astrobiological Research Laboratory, Sun Yat-Sen University

Welcome to the 4th APSCO & ISSI-BJ Space Science School at Sun Yat-sen University's Zhuhai Campus! It is our immense pleasure to host you at the Planetary Environmental and Astrobiological Research Laboratory. We hope this event will be a vibrant hub for exchanging pioneering ideas and fostering future collaborations in space science. Wishing you all a fruitful and inspiring time here in Zhuhai.

PROGRAM

Monday November 03 2025		
07:00–07:45	Registration	
07:45–08:00	Welcome Speeches & Introduction to the School	
Session 1: Solar Activity		
08:00–10:30	Introduction to Solar Physics Research	Jiajia Liu
10:30–11:00	Coffee Break	
11:00–12:10	From the Solar Atmosphere to the Solar Wind	Pengfei Chen
12:10–13:30	Lunch Break	
13:30–14:40	Coronal Mass Ejections: the Largest Eruptive Phenomenon on the Sun	Pengfei Chen
Session 2: Magnetosphere & Heliosphere (Solar Wind)		
14:40–15:50	Magnetosphere of the Inner & Outer Planets	Zhenguang Huang
15:50–16:30	Group Photo & Coffee Break	
16:30–17:40	Magnetosphere of the Inner & Outer Planets	Zhenguang Huang

Tuesday November 04 2025		
08:00–10:30	Unveiling Giant Planet Magnetospheric Dynamics: Insights into Planetary Space Weather	Shengyi Ye
10:30–11:00	Coffee Break	

Session 3: Ionosphere & Earth Upper Atmosphere

11:00–12:10	The Coupled Ionosphere-Thermosphere System	Jing Liu
12:10–13:30	Lunch Break	
13:30–16:00	The Coupled Ionosphere-Thermosphere System	Jing Liu
16:00–16:30	Coffee Break	
16:30–17:40	The Coupled Ionosphere-Thermosphere System	Jing Liu

Wednesday November 05 2025

Session 4: Space Weather–Effects on Industry & Society

08:00–10:30	Space Weather: From Aurora to Solar Storms	Ercha Aa
10:30–11:00	Coffee Break	
11:00–12:10	Solar Flare & CME Forecasting	Jingjing Wang
12:10–13:30	Lunch Break	
13:30–14:40	Solar Flare & CME Forecasting	Jingjing Wang
14:40–16:00	Introduction of the Working Groups	
16:00–16:30	Coffee Break	
16:30–17:30	Introduction of the Working Groups	

Thursday November 06 2025

09:00–12:30	Working Groups, Coffee Break Available at Any Time
12:30–14:00	Lunch Break
14:00–17:00	Working Groups, Coffee Break Available at Any Time
18:00–	Banquet Dinner

Friday November 07 2025

09:00–12:30	Working Groups, Coffee Break Available at Any Time	
12:30–14:00	Lunch Break	
14:00–17:00	Working Groups, Coffee Break Available at Any Time	

Saturday 08 November:

09:00–12:30	Working Groups, Coffee Break Available at Any Time	
12:30–14:00	Lunch Break	
14:00–17:00	Visiting Local Laboratories	

Sunday November 09 2025

Free time, but Optional to Work on the Projects for Working Groups

Monday November 10 2025

09:00–10:00	WG1 Presentation	
10:00–11:00	WG2 Presentation	
11:00–11:30	Coffee Break	
11:30–12:30	WG3 Presentation	
12:30–13:30	WG4 Presentation	
13:30–15:00	Lunch Break	
15:00–16:00	Career Talk–Life after PhD	Dmitrij Titov
16:00–16:30	Closing Remarks	
16:30–	End of Workshop	

PRACTICAL INFORMATION

Registration

Time: Monday, November 03, 07:00-07:45

Fee: Applicants under APSCO are fully supported. For all other participants the registration fee is set at:

- *Standard Registration Fee:* 2,200 RMB (310 USD).
- *Combined Registration & Accommodation Package:* 3,500 RMB (500 USD). This package includes the registration fee and hotel stay.

Payment of the fee must be done **upon arrival, in cash or via WeChat Pay**.

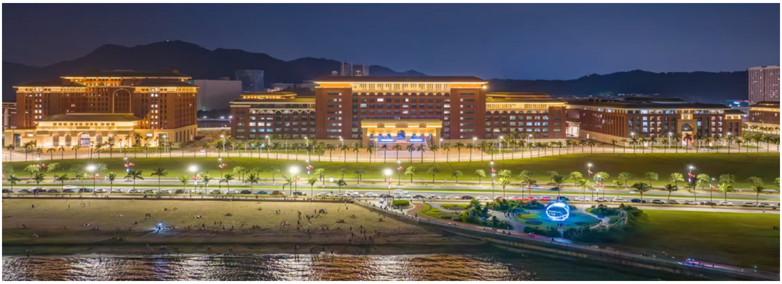
Venue

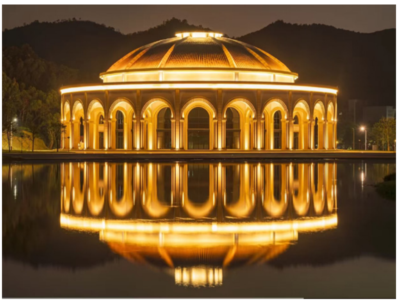
The school will be held at Sun Yat-sen University in Zhuhai, Guangdong province, China

Address
Sun Yat-Sen University Zhuhai Campus, Xiangzhou District, Zhuhai, Guangdong Province, 519082, China (广东省珠海市香洲区中山大学珠海校区)

Sun Yat-sen University

Sun Yat-sen University, founded by Dr. Sun Yat-sen, has an educational tradition spanning over 100 years. Under the direct supervision of the Ministry of Education of the People's Republic of China, and strongly supported by both the Ministry and Guangdong Province, Sun Yat-sen University has developed into a modern comprehensive university that enjoys a reputation as a top-tier university nationally and a renowned university internationally.





Visa-Free Entry Policies

You may be able to enter China without a visa under one of the following schemes. Please verify if you qualify based on your nationality and travel plans.

VISA-FREE TRANSIT POLICY (TRANSIT WITHOUT VISA – TWOV)

Foreign nationals from eligible countries can transit through China without a visa under the 72-hour, 144-hour, or 240-hour visa-free transit policy, depending on the port of entry.

Duration: Up to 240 hours (10 days) in selected cities and provinces.

Important: Travelers using this policy cannot change to another visa type from within China. Ensure that your departure flight is booked and falls within the allowed period.

Conditions:

- You must hold a valid passport and a confirmed onward ticket to a third country or region (not returning to the country you came from).
- Your stay is limited to the designated area of entry (e.g., Guangdong Province when entering via Guangzhou or Shenzhen).
- You must depart China within the permitted time (72 / 144 / 240 hours, depending on the city).

COUNTRIES ELIGIBLE TO THE 30 DAYS VISA-FREE ENTRY TO CHINA

Schengen Agreement Countries:

Austria, Belgium, Bulgaria, Croatia, Cyprus, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Italy, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland.

Other European Countries:

Andorra, Ireland, Monaco, Montenegro, North Macedonia.

American Countries:

Argentina, Brazil, Chile, Peru, Uruguay.

Asian Countries:

Brunei, Japan, South Korea, Malaysia, Thailand, Bahrain, Kuwait, Oman, Saudi Arabia.

If you are not from a country eligible for visa-free entry to China, *you must apply for a tourist visa (L visa)* before traveling.

Prepare Required Documents

- A valid passport with at least six months of remaining validity and at least one blank visa page.
- A completed visa application form (available online or at the Chinese embassy/consulate).
- A recent passport-sized photo (usually 2x2 inches or 33x48 mm, depending on consulate requirements).
- Proof of travel arrangements, such as flight tickets and hotel reservations.
- Sometimes, a detailed travel itinerary is requested.

Submit Your Application

You can apply at the Chinese embassy or consulate in your country, or through a visa application service center if one exists near you. Some consulates also allow online pre-registration, but the original documents are usually required in person.

Pay the Visa Fee

Visa fees vary depending on your nationality and the number of entries requested (single, double, or multiple entries). Payment methods differ by location, so check the consulate's instructions carefully.

Attend an Interview if Required

In some cases, the embassy or consulate may request an in-person interview to verify your application details.

Wait for Processing

Processing times generally range from 4 to 10 business days, depending on the consulate and service type (standard or expedited).

Collect Your Visa

Once your visa is approved, you will need to collect your passport with the visa sticker. Double-check all information on the visa for accuracy.

Transportation

Sun Yat-Sen University Zhuhai Campus, is located approximately 57 kilometers away from the Zhuhai Jinwan Airport (see Figure 1) and 79 kilometers away from Shenzhen Baoan International Airport (see Figure 2).

Besides, the hotel is situated within a short walking distance of the lecture campus.

Figure 1. Zhuhai Jinwan Airport to Sun Yat-Sen University Zhuhai Campus (Red Spot: Venue, Distance from the Airport: 47 km, Duration: 25 mins by car.)

Figure 2. Shenzhen Baoan International Airport to Sun Yat-Sen University Zhuhai Campus (Red Spot: Venue, Distance from the Airport: 79 km, Duration: 74 mins by car.)

There are 2 ways of transportation available from the airport to the venue.

1. *By Van (arranged by SYSU)*

The organizers will pick you up at the domestic or international arrival exit of Shenzhen Baoan International Airport and take you to Sun Yat-Sen University Zhuhai Campus. Look for the banner of the Shool as shown below.

There will be arranged two vans on November 2nd and two vans on November 11th, based on the time of arrival and departure of the students. The exact time will be given a couple of days before the start of the School via email.

2. By Taxi (additional)

Participants can take a taxi from the airport outside of the Terminal.

The taxi fare depends on the driver. Usually, it costs about 70 yuan to get from the airport to the venue.

Note: **We do not refund taxi fares.**

If you do not speak Mandarin, you might want to use the following text and show it to the taxi driver to indicate where you want to go:

- Sun Yat-Sen University Zhuhai Campus, Xiangzhou District, Zhuhai, Guangdong Province, 519082, China. Thank you!

“请把我送到广东省珠海市香洲区中山大学珠海校区.谢谢!”

Accommodation

The accommodation arrangements will be made by the organizers. Please make sure to send your arrival/departure dates to us so that we can book the hotel for you on time.

Note that although the cost of the accommodation is covered, all other expenses in the hotel will be deducted from your check-in deposit.

Qiju Hotel (精品民宿)

Address: 918 Tangqi Road, Xiangzhou District, Zhuhai, Guangdong Province, China (广东省珠海市香洲区唐琪路918号 精品民宿)
Phone: +86 137 2788 6998

Meals

Meals will be provided at the Sun Yat-sen University cafeteria, as well as coffee break. The cost of the meals is included in the registration fee.

Useful Information

Credit Cards: Credit and debit cards can be used in ATMs displaying the appropriate sign. Credit cards are accepted in major shopping zones and high level restaurants but keep some cash handy just in case.

Drinking Water: Avoid drinking tap water directly. Bottled water and mineral water can be found in convenience stores and drink stalls. The price is 2-10 yuan RMB per bottle.

Contact Persons

Ms. Francesca Garfagnoli
PR and Editorial Manager
International Space Science Institute-Beijing (ISSI-BJ)
Mobile: +86 195 6873 9884
Email: g.francesca@issibj.ac.cn

Ms. Charis Xiong
E&T Manager of Education and Training Department
Asia-Pacific Space Cooperation Organization (APSCO)
Mobile: +86 18611345520
Email: charis@apsco.int

LECTURERS & TUTORS

Lecturers

Jiajia Liu

University of Science and Technology of China, China

Dr. Jiajia Liu is a professor at the University of Science and Technology of China and a recipient of the National Overseas High-Level Talent Recruitment Programs. He received his PhD degree in 2015 from the University of Science and Technology of China. After that, he continued his research at the University of Science and Technology of China, University of Sheffield, and Queen's University in Belfast. In 2018, Dr. Liu was invited to attend the STEM for Britain event in the UK Parliament. In 2019, he became the first Chinese recipient of the International Alexander Chizhevsky Medal. That same year, he was elected as one of the 8 members of the UK Solar Physics Council of the Royal Astronomy Society and was invited to serve as a panel member (later the vice chair) for the international space weather and space climate awards from 2019-2023. Currently, Dr. Liu is a member of the International Astronomical Union, and a reviewer for the IAU Office for Astronomical Development. His major research interests lie in the physical processes of solar phenomena with various scales and the interplanetary responses to solar eruptive events. He has published 70+ papers and has got ~1500 citations.

Lecture title:

Introduction to Solar Physics Research

Abstract:

This lecture provides a foundational overview of solar physics research, a discipline dedicated to understanding the Sun's structure, dynamics, and impacts on Earth and the solar system. It begins by outlining key information of the Sun and solar physics research. Solar phenomena, including sunspots, solar flares, coronal mass ejections (CMEs), and the solar wind, will also be introduced with their physical origins and role in the Sun's activity cycle briefly explained. This lecture will also highlight critical research tools, from ground-based telescopes to space mission, which enable high-resolution observations of

the Sun's atmosphere and the interplanetary space. Finally, it touches on the practical relevance of applying machine learning techniques to solar physics studies..

Pengfei Chen

Nanjing University, China

Dr. Chen is a professor in School of Astronomy and Space Science, Nanjing University, China. He got his PhD in 1999 at Nanjing University, and did his postdoc at Kyoto University in Japan. His research interests include solar flares, coronal mass ejections, solar filaments, Moreton wave and EIT waves. He serves as an associate editor for the journals "Reviews of Modern Plasma Physics" and "Acta Astronomica Sinica". He is also a scientific editor of "Science China Physics Mechanics Astronomy" and "Universe". In 2017, he was awarded the Asian-Pacific Solar Physics Young Career Award.

1st Lecture title:

From the Solar Atmosphere to the Solar Wind

Abstract:

In this talk, I will introduce the structure of the solar atmosphere (including the photosphere, chromosphere, corona) and how the corona naturally evolves to solar wind. For the corona part, focus will be put on solar filaments. For example, I will explain how solar filaments are formed..

2nd Lecture title:

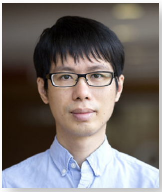
Coronal Mass Ejections: the Largest Eruptive Phenomenon on the Sun

Abstract:

In this talk, I will introduce how coronal mass ejections (CMEs) were discovered, the typical observational features of CMEs, the standard model of CMEs, and various triggering mechanisms for CMEs.

Zhenguang Huang

University of Science and Technology of China, China



Professor at the School of Earth and Space Sciences, University of Science and Technology of China (USTC). He earned his B.S. degree from USTC in 2008 and his Ph.D. from the University of Michigan in 2014. His research interests mainly focus on developing and applying advanced numerical simulations to solve fundamental problems in space and plasma physics. This includes investigating the coronal heating problem, simulating the global structure of the solar wind, and modeling the global magnetospheres of Earth, other solar system bodies, and exoplanets. He is a core developer of BATS-R-US (Block Adaptive Tree Solar Wind Roe-Type Upwind Scheme, a highly versatile multi-physics MHD code using block-adaptive grids) and SWMF (Space Weather Modeling Framework, a comprehensive framework that can couple and execute about a dozen different space physics models simulating domains from the surface of the Sun to the upper atmosphere of the Earth). He is also a co-developer of the operational Geospace Model Version 2.0 at NOAA's Space Weather Prediction Center (SWPC), which provides real-time forecasts of geomagnetic disturbances.

Lecture title:

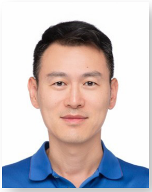
Magnetosphere of the Inner & Outer Planets

Abstract:

The interaction between solar wind and planets is a fundamental and complex problem in space science. Solar wind is a continuous stream of plasma escaping from the Sun's atmosphere and flows into the entire heliosphere. Its interaction with planets varies significantly depending on whether a planet possesses an intrinsic magnetic field, leading to distinct categories of planetary responses to the solar wind. Planets with an intrinsic magnetic field, e.g., Earth and outer planets, have a global magnetosphere that can shield the planets from direct impact of solar wind. In contrast, planets without an intrinsic magnetic field, e.g., Mars, develop a much smaller induced magnetosphere. This lecture will cover the basics of the interactions between solar wind and different planets in the solar system. It will discuss the characteristics of different planets and their implications of solar wind - planet interactions. It will also cover the impact of space weather events, e.g., Coronal Mass Ejections (CMEs), on the planetary magnetosphere.

Shengyi Ye

Southern University of Science and Technology, China



Dr. Shengyi Ye currently serves as a Professor in the Department of Earth and Space Sciences at the Southern University of Science and Technology (SUSTech). He received Bachelor of Science in Physics from Tsinghua University in 2000 and Ph.D. in Space Physics from Dartmouth College, USA, in 2007. Subsequently, Dr. Ye worked at the Department of Physics and Astronomy at the University of Iowa, where he conducted research primarily based on data from NASA's Cassini and Juno missions. Dr. Ye has published more than 90 peer-reviewed papers in internationally renowned journals such as Science, Geophysical Research Letters, and Journal of Geophysical Research. He served as the Associate Director of the Planetary Physics Committee of the Chinese Geophysical Society. He specializes in space plasma physics and planetary magnetospheres, with a focus on dust detection in space, dust–plasma interactions, radio emissions, and magnetospheric electrodynamics.

Lecture title:

Unveiling Giant Planet Magnetospheric Dynamics: Insights into Planetary Space Weather

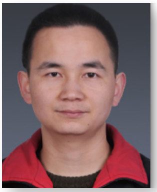
Abstract:

Solar System's diverse planetary magnetospheres serve as natural laboratories for understanding planetary space weather. These magnetic environments respond not only to solar wind variability but also to internal plasma sources, rotation-driven processes, and complex magnetosphere–ionosphere couplings. Recent observations of radio emissions and magnetic field perturbations have transformed our understanding of these systems, revealing how magnetic reconnection, plasma instabilities, and field-aligned currents accelerate electrons and generate auroral activity. Ultraviolet auroral imaging complements these data, mapping the spatial and temporal evolution of energy transfer and dissipation across each planet's magnetosphere. By combining radio diagnostics, magnetic field measurements, and auroral observations, we obtain a coherent, multi-scale picture of how solar wind dynamics and internal drivers shape planetary magnetospheric variability. Comparative analysis among the giant planets reveals both universal mechanisms and distinct magnetic

geometries that control energy flow, plasma transport, and auroral morphology. These insights not only deepen our understanding of magnetospheric processes within the Solar System but also provide a foundation for interpreting magnetized exoplanetary environments—linking planetary space weather from local to heliospheric and extrasolar scales.

Jing Liu

Shandong University, China



My career in space physics spans over a decade of dedicated research on magnetosphere-ionosphere-thermosphere coupling, beginning with my Ph.D. at the Key Laboratory of Earth and Planetary Physics within the Chinese Academy of Sciences. Following my doctorate, I pursued international postdoctoral positions at IGGCAS in China, the National Institute of Polar Research in Japan, and the National Center for Atmospheric Research (NCAR) in the USA, where I advanced to Project Scientist, focusing on theoretical modeling and data assimilation. In 2019, I joined Shandong University as a Professor, where I perform research on geospace system dynamics. My work, documented in 90+ publications including papers in Nature Physics and leading geophysical journals, has earned recognition, including the Fu Chengyi Youth Science and Technology Award (2022), and funding from prestigious programs such as the NSFC Excellent Young Scientist Program. I actively contribute to the academic community as an editorial board member for EPP, a frequent reviewer for journals including Nature and GRL, and an organizer of international workshops, aiming to advance understanding of cross-scale geospace processes and their societal impacts.

Lecture title:

The Coupled Ionosphere-Thermosphere System

Abstract:

In this talk, I wil give a brief introduction about the ionosphere-thermosphere (IT) system, which is a dynamically coupled region where internal ion-neutral interactions and external forcings—solar radiation, magnetospheric processes, and upward-propagating atmospheric waves—collectively govern its behavior. Solar extreme

ultraviolet (EUV) radiation serves as the primary ionization source, driving photochemical processes that determine electron density distributions, while magnetospheric energy injection during geomagnetic activity (e.g., particle precipitation and high-latitude electric fields) alters thermospheric composition and induces storm-enhanced density anomalies. Internally, collisions between ions and neutrals facilitate momentum transfer, particularly in the 100–150 km altitude range, influencing neutral winds and ion drifts that regulate large-scale IT dynamics. The system's response to external drivers is further modulated by neutral-plasma coupling, where disturbances like traveling atmospheric waves alter ionospheric electron density and thermospheric circulation globally. Recent advancements in whole-atmosphere models (e.g., WACCM-X) integrate these processes, revealing the profound impact of cross-scale interactions on space weather predictability. Understanding this coupled system is essential for mitigating technological impacts on satellite operations and communication networks.

Ercha Aa

National Space Science Center, Chinese Academy of Sciences, China

Dr. Ercha Aa is a Research Scientist at the National Space Science Center, Chinese Academy of Sciences. He received Bachelor's degree from the Wuhan University and then got his Ph.D. from the Peking University. Prior to his current role, he worked at the University of Michigan from 2017 to 2019 and then worked at the Massachusetts Institute of Technology's Haystack Observatory from 2019 to 2024. His research focuses on the terrestrial ionosphere, thermosphere, and space weather.

Lecture title:

Space Weather: From Aurora to Solar Storms

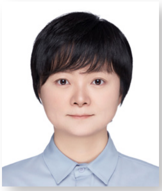
Abstract:

Space weather encompasses the dynamic conditions in Earth's space environment, driven primarily by solar activity. Space weather affects so much of our modern society that we need a good explanation of where it comes from, what it is, and how it affects our life. This course

explores the basic spectrum of space weather phenomena, from the mesmerizing auroras to the potent solar storms like flares and coronal mass ejections, as well as their profound terrestrial consequences. Space weather poses significant risks to modern technology, which can severely disrupt satellites, radio communications, power grids, and GNSS systems. By studying the pathway from the solar eruption to Earth's upper atmosphere, we advance our ability to forecast space weather events and enhance the resilience of our vital technological infrastructure.

Jingjing Wang

National Space Science Center, Chinese Academy of Sciences, China



Professor at Space Environment Prediction Center, State Key Laboratory of Solar Activity and Space Weather, National Space Science Center, Chinese Academy of Sciences, since 2013. She earned Bachelor's degree from Peking University in 2008, followed by a Doctor's degree from University of Chinese Academy of Sciences in 2013. Her research focuses on forecasting solar eruptive activities (flares, coronal mass ejections) and their impacts on Earth, including machine-learning - driven solar flare prediction, coronal mass ejection modeling & interplanetary propagation forecasting, and geomagnetic storm prediction.

Lecture title:

Solar Flare & CME Forecasting

Abstract:

Solar flares and coronal mass ejections (CMEs) are primary disturbance sources of space weather, profoundly affecting the heliosphere and Earth's environment. Forecasting these solar eruptive activities integrates multi-wavelength observational data (from ground-based and space-borne detectors), analyzes coronal magnetic field topology, and uses advanced numerical models to predict their initiation, intensity, and evolution. After eruption, CMEs propagate through the interplanetary medium, interacting with solar wind, interplanetary magnetic fields, and other ejecta—

modulating their speed, structure, and geoeffectiveness. These events disrupt Earth's systems: sparking geomagnetic storms to damage power grids and pipelines, impairing satellite operations (communication, navigation), and threatening astronaut safety and high-tech systems. Hence, accurate forecasting of flares and CMEs, plus understanding their interplanetary propagation, is essential to mitigate space weather hazards and safeguard technology-reliant societies..

Working Groups' Tutors

Zhenjun Zhou

Sun Yat-sen University, China

He received his Bachelor's degree in Geophysics and Ph.D. in Space Physics from the University of Science and Technology of China. He is currently an Associate Professor at the School of Atmospheric Sciences, Sun Yat-sen University, working with the Planetary Environmental and Astrobiological Research Laboratory. He has also spent one year as a visiting scholar at George Mason University. His research has been devoted to observational studies of magnetohydrodynamic instabilities and thermal radiative processes in the solar atmosphere, where he has achieved systematic results, particularly on the three-dimensional evolution of eruptive filaments and the interplanetary propagation of ICMEs.

Sun Tianran

National Space Science Center, Chinese Academy of Sciences, China

Dr. Tianran Sun is a research professor in the National Space Science Center, Chinese Academy of Sciences. She got PhD of Space Physics from the University of Chinese Academy of Sciences in 2012. Her research interests include solar wind-magnetosphere coupling, global imaging of the planetary space environment, and numerical simulations. She serves as co-PI of the soft X-ray imager of the Solar wind Magnetosphere Ionosphere Link Explorer (SMILE), co-chair of the SMILE Modeling Working Group, and Member of the Science Committee for the Chang'E Mission, China's Lunar Exploration.

Xin Wan

Sun Yat-sen University, China

Associate Professor at the Planetary Environmental and Astrobiological Research Laboratory (PEARL), Sun Yat-sen University since 2024. Received Bachelor's and Doctoral degrees from Wuhan University in 2015 and 2020, respectively. His main research topic focuses on the terrestrial and planetary ionosphere, particularly the intermediate-scale structures and their dynamical response to internal and external drivers.

Yudong Ye

Sun Yat-sen University, China

He holds a Bachelor's degree in Geophysics from the University of Science and Technology of China and a Ph.D. in Space Physics from the Chinese Academy of Sciences. He is currently a Postdoctoral Researcher at Sun Yat-sen University, working in the Planetary Environmental and Astrobiological Research Laboratory. His research interests center on applying machine learning and data-driven approaches to heliophysics and space weather forecasting, with a particular focus on the role of interplanetary disturbances such as coronal mass ejections and solar wind structures. He also investigates the interactions between solar activity and planetary environments, including studies of the Martian ionosphere and magnetosphere. Beyond his research, he has participated in several international collaborations and projects, contributing to advancing our understanding of solar–terrestrial and solar–planetary connections.

PARTICIPANTS

No.	Name	Affiliaton
STUDENTS		
1	Aboubakr Alwaer	Regional Center for Remote Sensing of North Africa States, North Africa
2	Aldo Arriola	Directorate of Astronomy and Space Sciences, Peruvian Space Agency, Peru
3	Memoona Ashraf Ashrafi	Pakistan Space Weather Center, Pakistan Space & Upper Atmosphere Research Commission, Pakistan
4	Irmuunzaya Batbold	Institute of Astronomy and Geophysics, Mongolian Academy of Sciences, Mongolia
5	Mehmet Erbasan	Launch Systems and Technologies Department, Turkish Space Agency, Türkiye
6	Xiaoquan Feng	Beijing University of Aeronautics and Astronautics, China
7	Batzul Ganbold	Laboratory of Electronics and Photonics, Institute of Physics and Technology, Mongolian Academy of Sciences, Mongolia
8	Yuqi Gong	National Space Science Center, Chinese Academy of Sciences, China
9	Hasan Ersel Gürel	Department of Space Systems, Missions and Technologies, Turkish Space Agency, Türkiye
10	Rahat Ashraful Haq	Bangladesh Space Research and Remote Sensing Organization, Bangladesh
11	Jafarpour Meisam Honari	Department of Astronomy and Space exploration, Iranian Space Agency, Iran
12	Ali Reza Honarvaran	Iran Space Reserch Center, Iran

13	Jesús Izquierdo	University of Piura, Peru
14	Saber Karami	Center for Space Research, Iranian Space Research Center, Iran
15	Khushlim Khan	Astronomy Division, Pakistan Space & Upper Atmosphere Research Commission, Pakistan
16	Jidapa Lakronwat	Department of Physics, Mahidol University, Thailand
17	Sihan Lei	Nanjing University, China
18	Dalin Li	National Space Science Center, Chinese Academy of Sciences, China
19	Pradiphat Muangha	Research Group, National Astronomical Research Institute of Thailand, Thailand
20	Xiaojing Sun	Beihang University, China
21	Naim Islam Talukder	Bangladesh Space Research and Remote Sensing Organization, Bangladesh
22	Xiaofei Wu	National Space Science Center, Chinese Academy of Sciences, China
23	Jingru Xu	Hangzhou International lnnovation Institute, Beihang University, China
24	Li Yan	Beihang University, China
25	Changhao Zhai	Nanjing University, China
26	Duan Zhang	National Space Science Center, Chinese Academy of Sciences, China
27	Hongkai Zhang	National Space Science Center, Chinese Academy of Sciences, China
28	Yingjie Zhang	National Space Science Center, Chinese Academy of Sciences, China
29	Limin Zhao	Beihang University, China

4th APSCO & ISSI-BJ Space Science School

LECTURERS

1	Ercha Aa	National Space Science Center, Chinese Academy of Sciences, China
2	Pengfei Chen	Nanjing University, China
3	Zhenguang Huang	University of Science and Technology of China, Chinese Academy of Sciences, China
4	Jiajia Liu	University of Science and Technology of China, Chinese Academy of Sciences, China
5	Jing Liu	Shandong University, China
6	Jingjing Wang	National Space Science Center, Chinese Academy of Sciences, China
7	Shengyi Ye	Southern University of Science and Technology, China

TUTORS

1	Tianran Sun	National Space Science Center, Chinese Academy of Sciences, China
2	Xin Wan	Sun Yat-sen University, China
3	Yudong Ye	Sun Yat-sen University, China
4	Zhenjun Zhou	Sun Yat-sen University, China

STAFF		
1	Yutian Cao	Sun Yat-sen University, China
2	Jun Cui	Sun Yat-sen University, China
3	Richard de Grijs	Macquarie University, Australia; International Space Science Institute-Beijing, China
4	Francesca Garfagnoli	International Space Science Institute-Beijing, China
5	Robert von Fay-Siebenburgen	The University of Sheffield, UK
6	Yihan Xie	Sun Yat-sen University, China
7	Muzi Xiong	Asia-Pacific Space Cooperation Organization
8	Yansong Xu	Asia-Pacific Space Cooperation Organization
9	Lin Zhang	Sun Yat-sen University, China
10	Kaiwen Zhang	Sun Yat-sen University, China

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