An Introduction to Space Weather

Space weather is an emerging field of space science focused on understanding societal and technological impacts of the solar–terrestrial relationship. The Sun, which has tremendous influence on Earth's space environment, releases vast amounts of energy in the form of electromagnetic and particle radiation that can damage or destroy satellite, navigation, communication, and power distribution systems, and injure or kill astronauts. This textbook introduces the relationship between the Sun and Earth, and shows how it impacts our technological society.

One of the first undergraduate textbooks on space weather aimed at non-science majors, it uses practical aspects of space weather to introduce space physics and give students an understanding of the Sun–Earth relationship. Definitions of important terms are given throughout the text. Each chapter contains key concepts, supplements, and review questions to help students understand the materials covered. This textbook is ideal for introductory space physics courses.

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Preface

In the last few decades our technological civilization has become dependent on satellites for global communication, navigation, and commerce. We have also begun the long journey to explore the Moon, Mars, and our Solar System.

This exploration has led to some amazing discoveries about our dynamic Sun and its interaction with Earth. We now know that the Sun is a variable star that expels high-energy particles and deadly radiation continuously out into space. This radiation can impact and destroy technological systems and is one of the major concerns for human space exploration.

In the 1990s, the commercial satellite industry boomed, with direct-satellite-to-home TV markets and satellite communication options expanding. In 2000, the satellite communications industry was doing nearly $100 billion per year of business with nearly a hundred new satellites launched each year. With the increased commercial businesses and the reliance of different markets on space, society began to notice when something went wrong in space.

Galaxy IV was an operating and profitable communications satellite until May 19, 1998, when, after experiencing weeks of intense radiation generated by the Sun and the Sun's interaction with the Earth's space environment, it failed. Galaxy IV carried the signals of over 90% of North America's pagers and several major broadcast networks, including the US National Public Radio (NPR) and CBS. Without the $200 million satellite, millions of pager messages, NPR radio, and CBS television programs never made it to their intended audience. Radio and TV producers were left scrambling to fill dead-air time and medical doctors and business people found themselves out of contact with their hospitals and clients. In all likelihood Galaxy IV was a victim of a space weather storm. Space storms can not only damage or destroy orbiting satellites, but can also injure or kill astronauts, degrade or blackout certain radio and navigation communications, and cause regional power failures by destroying critical components of electrical power grids. With the continued growth of the satellite communications industry and our growing dependence on wireless communication and instant access to global information, we

are becoming more and more susceptible to problems caused by space weather.

This textbook introduces the reader to the emerging field of space weather using an approach that is both descriptive and quantitative. The mathematical sophistication of the reader is assumed to be at the level of high-school algebra. Since science is not just a collection of facts, but a process or way of understanding our natural world, the book attempts to answer the question "How do we know that?" by including discussions on the historical development of different concepts.

This book was derived from the notes for three undergraduate courses at UCLA – the first a freshman seminar, the second an Honors Collegium course, and the third a general education course for non-science majors entitled "The Perils of Space: an Introduction to Space Weather" first taught in Fall 2004.

Each chapter is divided into two parts: the main text describing space weather topics and supplements describing important physical concepts behind each topic. End-of-chapter problems allow students to delve deeper into aspects of the chapter. A list of key concepts is given at the beginning of each chapter, and the concepts are in bold in the main body of the text. Readers wishing to understand space weather should familiarize themselves with them. Definitions of important terms, which are given throughout the text, are indicated by bold page numbering in the index.

Acknowledgments

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