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Space Weather at Earth and its Relationship to Planetary Space Weather

J. P. Eastwood
The Blackett Laboratory, Imperial College London, London UK (jonathan.eastwood@imperial.ac.uk / Fax: +44-207-5947772)

Abstract

Space weather research at Earth largely concerns the practical impact of space plasma physics. In this overview talk we will consider the sources of space weather, areas of impact, and the monitoring of space weather including a presentation of the Sunjammer solar sail technology demonstration mission. We will then consider the concept of planetary space weather, and explore the differences and synergies that exist between this general research area and the study of space weather at Earth.

1. Introduction

At Earth, "Space weather refers to conditions on the Sun and in the space environment that can influence the performance and reliability of space-borne and ground-based technological systems, and can endanger human life or health." [1] As such, the concept of space weather and studies of space weather at Earth refer to a field of applied research where our basic knowledge and understanding of space plasma physics is used to predict, mitigate, and avoid risk that affects many aspects of everyday life [2].

2. Space weather at Earth

Since the Earth's magnetosphere is predominantly driven by the solar wind, the principal sources of space weather at Earth are generated by the Sun and include Coronal Mass Ejections (CMEs), Flares, Solar Energetic Particles and Corotating Interaction Regions (CIRs). Some of these phenomena have a direct effect (e.g. radio emission and energetic particles from flares), whereas CMEs and CIRs are plasma structures entrained in the solar wind which drive geomagnetic substorms and storms. Documented areas of impact include: ground infrastructure (power lines and pipelines), Global Navigation Satellite Systems (GNSS), air travel, satellites, and human spaceflight.

3. Monitoring space weather

Space weather is monitored and studied both using imaging and in situ measurements. Imaging (e.g. coronal, auroral) can be performed remotely and provides global knowledge of the system behaviour. In situ measurement is required for understanding in more detail the physical processes at work, particularly those processes that do not generate signatures that can be detected remotely. One of the most important in situ measurements is that of the solar wind upstream of the Earth: the interplanetary magnetic field orientation largely controls the space weather at Earth because as mentioned above the Earth's magnetosphere is largely solar wind driven. In this context, we will present Sunjammer, a solar sail technology demonstration mission that will carry a space weather payload to a point upstream of L1 in the solar wind, and is due to launch in 2014.

4. Planetary Space Weather

The concept of planetary space weather is somewhat different in focus from space weather at Earth. Although (to some extent) interest in space weather 'applications' is limited to those bodies where there may be human activity in the future (e.g. the Moon, asteroids and Mars), or perhaps where life may exist or have existed, we will argue that it is important to consider space weather at Earth in the wider context of planetary space weather for two reasons:

- The plasma physics and processes controlling the interaction of the solar wind with other planetary magnetospheres can be very different to those experienced at Earth, and so comparative studies examining other

planets are very important to gain a full understanding of the underlying physics.

- Conversely, the Earth's magnetosphere, which is well instrumented with multiple satellite missions, can be used as a laboratory to understand the basic processes at work, which may then be translated to other solar system bodies.

Conclusions

Space weather is of growing importance at Earth because it has been realised that it represents a significant threat to infrastructure resilience. In parallel, planetary space weather has arisen as a field of research which explores how space weather effects change as a result of different solar wind conditions, different magnetospheric configurations and different planetary inputs. As such, there is a strong synergy between the specific area of terrestrial space weather research and the more general planetary space weather studies.

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References

[1] US National Space Weather Program, www.nswp.gov

[2] Eastwood, J. P.: The Science of Space Weather, Phil. Trans. R. Soc. A, 366, pp. 4489-4900, 2008.