Chapter 1

Introduction, What is Space Weather?

In this introduction we briefly describe the term space weather and give motivation why that interdisciplinary field gained high interest. Examples will demonstrate the high relevance of space weather not only from the scientific point of view but from the social and economic aspect of our modern civilization.

Since this is a very modern topic, there appeared several monographs about that subject, e.g. a collection of space weather related topics\(^1\).

1.1 Definition of Space Weather

Modern society becomes strongly reliant to technologically advanced systems, often located in space such as telecommunication, navigation. Therefore, the conditions and variations in space where these satellites orbit the Earth are important to study and the question arises whether there are influences on such systems or not. We speak of geomagnetic disturbances in this connection. Systems that are susceptible to geomagnetic disturbances are satellites and power grids on Earth. That means that the geomagnetic environment is changed, but as we will see in the later chapters, these disturbances are triggered by our nearest star, the Sun.

It is generally accepted that the term \textit{space weather} refers to the time-variable conditions in the space environment that may effect space-borne or ground based technological systems.

According to the US National Space Weather Programme the definition is: \textit{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 and can endanger human life or health.}

Thus we see that the definitions are slightly different but we want to keep the first one because it also includes other effects apart from the Sun.

\(^1\)see e.g. P. Song, Howard J. Singer, George L. Siscoe, Paul Song, Space Weather, 2001, Am. Geophys. Union
CHAPTER 1. INTRODUCTION, WHAT IS SPACE WEATHER?

Since we strongly depend on satellite systems and their availability, it is crucial that these systems are in full operation. Moreover, in the worst case, human health or life can also be endangered by space weather. Therefore, there are social and economic aspects of this type of research: one tries to avoid consequences of space weather events by system design or efficient warning and prediction. During the last few years space weather activities have expanded world-wide. Examples for such activities which of course are of national and international interest are:

- US Space Weather Program,
- US-NASA’s Living With a Star program,
- ESA’s space weather program,
- SWENET, Space Weather European Network,
- SIDC, Solar influences data center at the Royal observatory in Belgium,
- Lund space weather center,
- The Australian IPS Radio and Space Services, the Australian Space Weather Agency,
- The Canadian Space weather program,

and many others (such as the Group in Oulu, Finland). Today, space weather is monitored from a worldwide net of ground stations and from space. Both types of observations are complementary. From space the whole electromagnetic spectrum of the Sun can be observed including UV and X-rays.

An overview about space weather, environment and societies can be found in the monograph by Lilenstein and Bornarel, 2005 [196].

1.2 The Triggers of Space Weather

The main cause for space weather effects is our Sun. It emits light at all wavelengths that reaches the Earth within about 8 minutes as well as a continuous stream of particles which is called the solar wind. During one solar activity cycle which has a period of about 11 years both radiation and solar wind are modulated. The energy of the Sun drives temperature, precipitation, atmospheric circulation, ocean currents, evaporation and cloud cover. The short wavelength radiation (UV, X-rays) triggers many chemical reactions in the upper atmosphere of the Earth and also the ozone level is modulated by solar activity. It was R.C. Carrington who observed on September 1, 1859 a white light flare\(^2\) that erupted from a group of sunspots and in the following night a great aurora was seen down to low geographic latitudes, even from Cuba. On the same night, a great magnetic disturbance was also recorded. For the first time it was recognized correctly, that a change on the Sun might have directly influenced the environment around the Earth.

\(^2\)The observations were reported to the Royal Astronomical Society