SPACE WEATHER

The term space weather refers to 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 that can affect human life and health.

Our modern hi-tech society has become increasingly vulnerable to disturbances from outside the Earth system, to those initiated by explosive events on the Sun:

1. **Flares** release flashes of radiation covering an immense wavelength range (from radio waves to Gamma-rays) that can, e.g., heat up the terrestrial atmosphere within minutes such that satellites drop into lower orbits.
2. **Solar Energetic Particles (SEP)**, accelerated to near-relativistic energies during major solar storms arrive at the Earth's orbit within minutes and may, among other things, severely endanger astronauts traveling through interplanetary space, i.e., outside the Earth's protective magnetosphere.
3. **Coronal Mass Ejections (CME)**, ejected into interplanetary space as gigantic clouds of ionized gas, that after a few hours or days may eventually hit the Earth and cause, among other effects, geomagnetic storms.

Space between the Sun and its planets is not empty as had been thought until the 1950s. It is filled by a tenuous magnetized plasma, which is a mixture of ions and electrons flowing away from the Sun: the solar wind. In fact, the Sun's outer atmosphere is so hot that not even the Sun's enormous gravity can prevent it from continually evaporating. The escaping plasma carries the solar magnetic field along, out to the border of the heliosphere where its dominance finally ends.

The solar wind (and the IMF carried with it) proves to be one key link between the solar atmosphere and the Earth system. Although the energy transferred by the solar wind is minuscule compared to both sunlight and those involved in Earth's atmosphere, the solar wind can pin-prick the Earth system which may react nonlinearly. There are indications of effects reaching down as far as the troposphere, and our increasingly sophisticated high-tech civilization can indeed notice them and does, at times, even suffer from them. That is why the role of the Sun and solar wind as drivers of space weather has gained attention recently.

The solar wind flow is diverted around Earth by its magnetosphere that is maintained by the Earth's intrinsic magnetic field. Solar wind particles cannot enter, unless there occurs a process called *magnetic reconnection* of interplanetary and planetary magnetic field lines. That may happen if the northward pointing Earth field on the front of the magnetosphere is hit by solar wind carrying a southward pointing interplanetary field. In such cases, significant geomagnetic disturbances of various kinds are initiated. Note that usually the IMF near the Earth does not have northward or southward pointing components. It is the intention of this section to describe the various effects by which the IMF can be titled such that major B_z south excursions do occur.

SPACE WEATHER APP

The Space Weather Tracker project is centered around understanding and visualizing the impact of space weather, which refers to the conditions in space that can affect both technology and human life. Events such as solar flares, solar energetic particles (SEPs), and coronal mass ejections (CMEs), originating from the Sun, can cause significant disruptions to satellites, power grids, communication systems, and even endanger astronauts traveling through space. These phenomena release bursts of radiation and charged particles that travel toward Earth, potentially causing geomagnetic storms, satellite malfunctions, and atmospheric disturbances.

The project aims to capture real-time data related to these solar events and present them in a user-friendly interface. It relies on live space weather data from APIs and visualizes parameters like solar wind speed, geomagnetic storm activity, and coronal mass ejections. The goal is to track the Sun’s influence on Earth's magnetosphere and technology systems by highlighting the interaction between the solar wind and Earth’s magnetic field, which can trigger significant disturbances. Through this, users can better understand the dynamic nature of space weather and its potential impact on modern technology.