Geomagnetic Indices and The Ring Current

Introduction

Since the Space Age, the study of the near Earth space environment has become of great importance due to the advent of electrical systems, radio communications, and satellites which are directly affected by the state of the space environment around the Earth. The study of the 'weather' of this space environment comes in many shapes and forms but has mostly centered around the analysis and prediction of disturbances in the environment. These disturbances have been dubbed 'geomagnetic storms', and their effects can range from inconsequential to, in the most severe cases, society altering.

Several features of this space environment create changes at the ground level as they vary which can be measured and assigned values. In this poster we focus on three such values (or indices): K_p, $F_{10.7}$, and Sym-H/Dst. The Sym-H/Dst index is of particular interest as it relates to one of the more prominent subsystems of the Earth's geospace environment, namely the ring current.

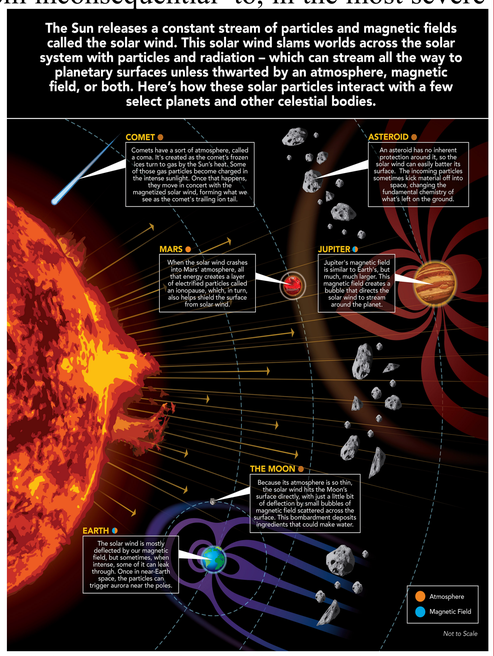
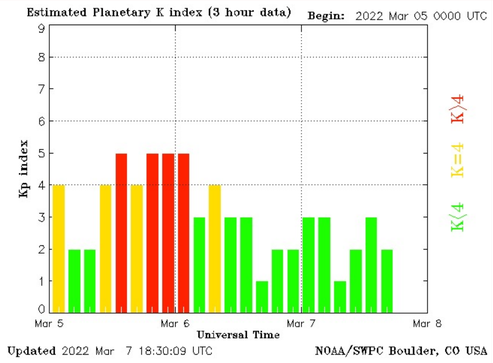


Photo taken from https://solarsystem.nasa.gov/resources/2288/the-solar-wind-across-our-solar-system/

K_p Index

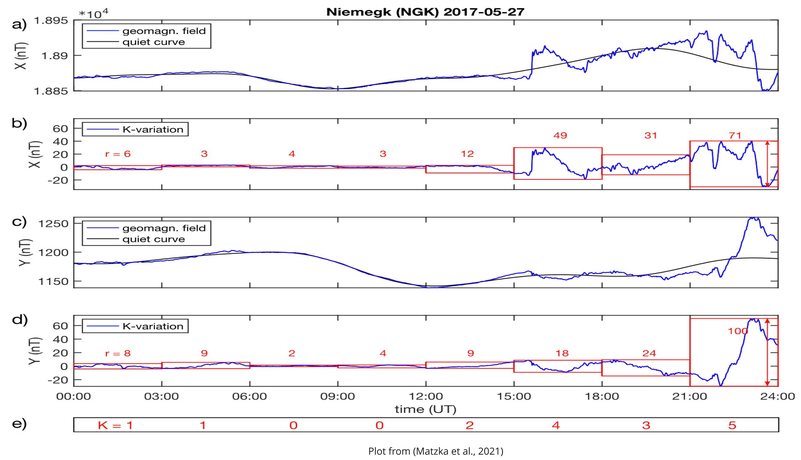
The first index of importance is the K_p index, which has been shown to have correlations with many different systems of the geospace environment (Matzka 2021). Several parameters of the ionospheric system correlate well with the Kp index, including ions flowing out of the ionosphere, thermospheric densities, and height integrated ionospheric conductance. But what is the K_p index? The K_p index is created from a network of 13 magnetic observatories



Plot Downloaded From https://www.swpc.noaa.gov/products/planetary-k-index

K_p Index (cont.)

located at latitudes lower than the latitudes auroras are known to occur at. For each three hours, the maximum variability of the field is used to assign a K_p value to the interval. When the K_p index is above 4, there are strong possibilities that the ionosphere and thermosphere regions are not nominal, and the transmission of radio communications are likely to be affected.



Plot from (Matzka et al., 2021)

Matzka, J., Stolle, C., Yamazaki, Y., Bronkalla, O., & Morschhauser, A. (2021). The geomagnetic *Kp* index and derived indices of geomagnetic activity. *Space Weather*, 19, e2020SW002641. https://doi.org/10.1029/2020SW002641

Bartels, J. (1957a). The technique of scaling indices K and Q of geomagnetic activity. *Annals of the International Geophysical Year*, **4**, 215–226.

$F_{10.7}$ Index

$F_{10.7}$ is a measure of the global activity on the surface of the Sun which is facing the Earth.

It can be used to determine how active the surface of the Sun is, which will in turn affect Earth's geospace environment.

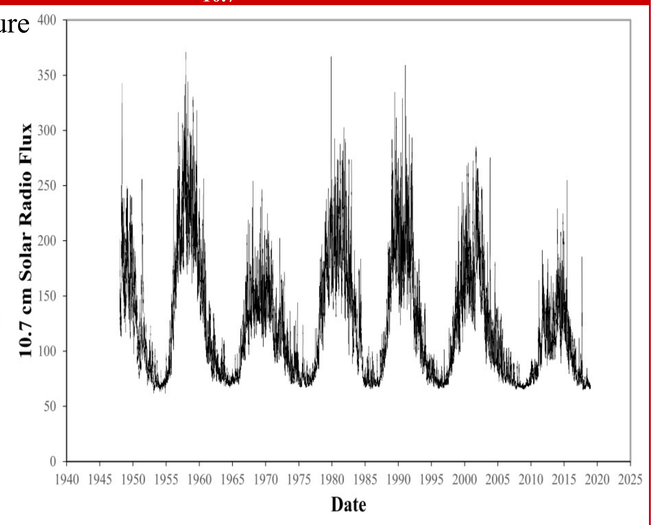


Figure 1 Daily adjusted $F_{10.7}$ index for the period 1948 – 2018.

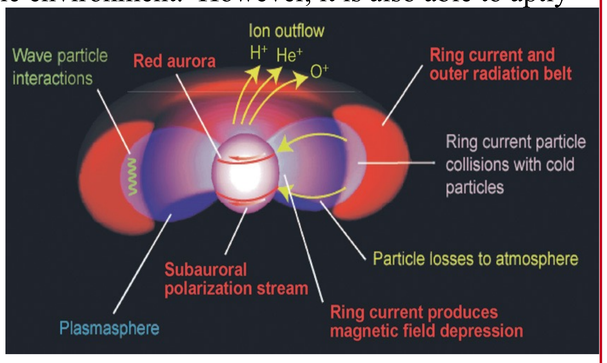
Plot from (Acero et al., 2019)

10.7 cm emissions can also be absorbed in the Earth's ionosphere, which can lead to heating and variability of scale heights of certain regions of the atmospheric system.

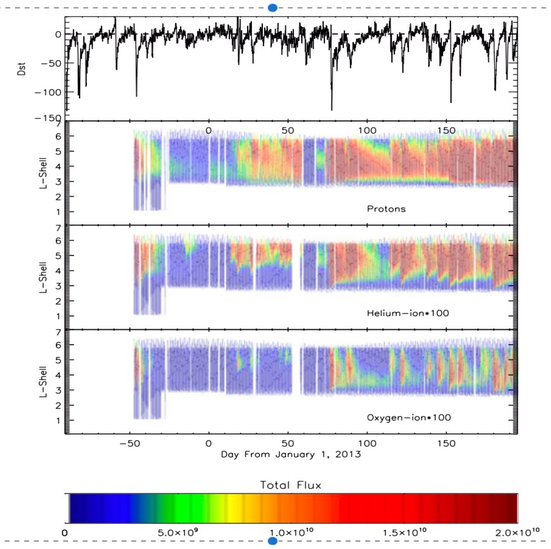
Acero, F.J., Vaquero, J.M., Gallego, M.C. *et al.* Extreme Value Theory Applied to the Daily Solar Radio Flux at 10.7 cm. *Sol Phys* **294,** 67 (2019). https://doi.org/10.1007/s11207-019-1457-z

Sym-H/Dst and The Ring Current

The third, but certainly not least, important geomagnetic index we highlight is the Sym-H/Dst index. We say Sym-H/Dst due to the highly related nature of these two indices. However, these values are calculated separately by different groups. Sym-H/Dst shares many characteristics with the K_p index in terms of indicating an active geomagnetic environment. However, it is also able to aptly quantify the state of an important subsystem in the Earth's near-space environment. This subsystem is the Earth's Ring Current, and has been and continues to be the subject of rigorous investigations. The structure of dips in Sym-H/Dst can also be used to determine what type of activity initiates geomagnetic storms. The ring current is fascinating from a fundamental physics standpoint, as well. The pioneering work of (Vaslyiunas, 1968) showed a new branch of thermodynamics which was previously unknown. However, most observations of this new thermodynamic regime have been limited to short timespans.



The proximity of the ring current to Earth and the advanced understandings of the Earth's system makes the ring current an ideal experimental environment to investigate this new regime, and to determine how it can affect populations of larger particles, such as hydrogen, helium, and oxygen.



Plot from (Gerrard et al., 2014)

Gerrard, A., Lanzerotti, L., Gkioulidou, M., Mitchell, D., Manweiler, J., Bortnik, J., and Keika, K. (2014), Initial measurements of O-ion and He-ion decay rates observed from the Van Allen Probes RBSPICE instrument, *J. Geophys. Res. Space Physics*, 119, 8813– 8819, doi:10.1002/2014JA020374.

Vasyliunas, V. M. (1968), A survey of low-energy electrons in the evening sector of the magnetosphere with OGO 1 and OGO 3, *J. Geophys. Res.*, 73(9), 2839– 2884, doi:10.1029/JA073i009p02839.

Moore T.E. (2007) Ring Current. In: Gubbins D., Herrero-Bervera E. (eds) Encyclopedia of Geomagnetism and Paleomagnetism. Springer, Dordrecht. https://doi.org/10.1007/978-1-4020-4423-6_279

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