CHAPTER 2

DATA

For the analysis, it is required to use geomagnetic indices, which are representatives of geomagnetic activity, and Interplanetary Magnetic Field (IMF) data in addition to f_0F2 ,which is used as a measure of Ionospheric variability, covering 20 years between 1973 and 1993. The geomagnetic data are the 3 hour planetary Kp index and Dst, and IMF which were compiled from SPIDR[1] of the NGDC[2]. The ionospheric data are the f_0F2 values and were compiled from Arkhangelsk (64.4 N; 40.5 E) and Slough (51.5 N; 0.6 W) Vertical Ionosondes.

2.1 Data Used

2.1.1 Interplanetary Magnetic Field

The Interplanetary Magnetic Field data is being measured by IMP[3]. The satellite measures the magnetic fields, plasmas and energetic particles[28]. Interplanetary Magnetic Field being a vector, the satellite measures the magnetic field in three components, one (B_x) of which is in Geocentric Solar Ecliptic (GSE) and two (B_y and B_z) are in Geocentric Solar Magentopsheric (GSM). Detailed information about coordinate systems can be found in Appendix A.

Within the interval of interest, data could only be retrieved hourly, although it was possible to find minutely for the data of more recent years. Due to the reason that all sort of data should be available for the analysis, the interval was selected to be between years 1973 and 1993 and the data frequency was selected as hour..

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[1] Space Physics Interactive Data Resource, http://spidr.ngdc.noaa.gov/spidr/index.jsp
[2] National Geophysical Data Centre, http://www.ngdc.noaa.gov/ngdc.html
[3] Interplanetary Monitoring Platform, http://nssdc.gsfc.nasa.gov/space/imp-8.html

The data was organized in such a way that the missing values are flagged with the number $1x10^{33}$ so that the missing values could be extracted easily. The unit used for the magnetic field was nano Tesla (nT).

From the whole dataset, as an example, January of 1973 data were drawn in Figure 2.1. As can be seen from the figure, the IMF values were highly variable.

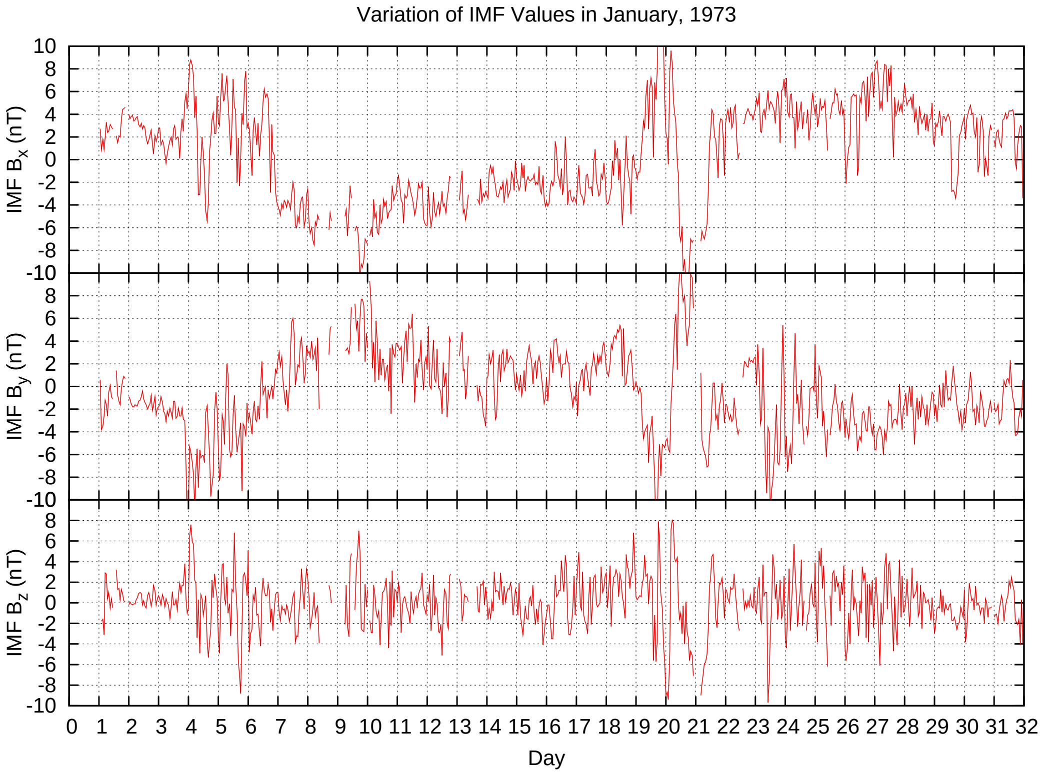

Figure 2.1: IMF Variation during January, 1973

2.1.2 Geomagnetic Indices

Daily regular magnetic field variations arise from current systems caused by regular solar radiation changes. Other irregular current systems produce magnetic field changes caused by the interaction of the solar wind with the magnetosphere, by the magnetosphere itself, by the interactions between the magnetosphere and ionosphere, and by the ionosphere itself. Thus, in order to analyze the variations in the geomagnetic field caused by these irregular current systems, geomagnetic indices were designed[29]. In this work, two of them, most frequently used ones, were employed in order to quantify and qualify the geomagnetic disturbances and to observe the behaviour of geomagnetic activity during disturbed conditions.

2.1.2.1 Kp

3-h planetary Kp index is a semi-logarithmic scale which is first designed to measure solar particle radiation by its magnetic effects[30]. Kp index is the mean standardized values of 13 different geomagnetic observatories between 44 degrees and 60 degrees northern and southern geomagnetic latitudes[29]. Since the first calculated Kp indices in 1938, there has been no data gap in the databases.

The maximum value of the Kp index is 9 and the values of Kp index are: 1-, 1, 1+, 2-, 2, 2+, 3-, 3, 3+, 4-, 4, 4+, 5-, 5, 5+, 6-, 6, 6+, 7-, 7, 7+, 8-, 8, 8+, 9- and 9. During geomagnetically quiet periods, the value of Kp index is less than 2+. The values between 2+ and 4+ indicates geomagnetically disturbed condition, whereas the values greater than 4+ mean a severe geomagnetic activity.

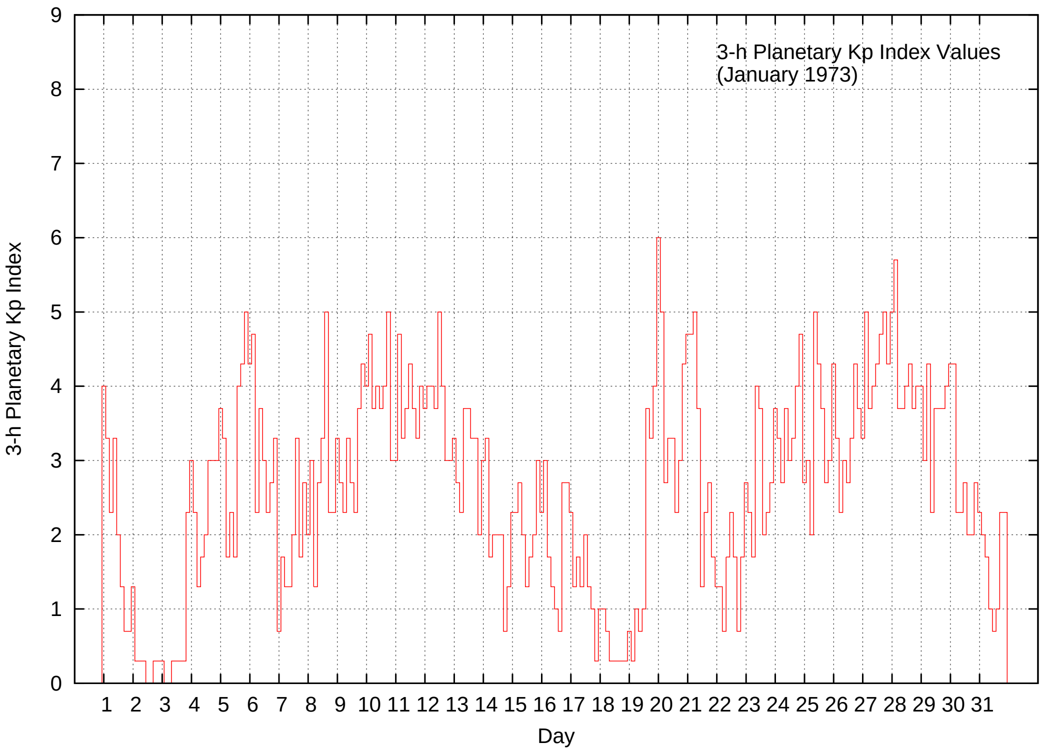

Figure 2.2: 3-h planetary Kp index variation during January, 1973

In Figure 2.2, a sample period was shown. As can be seen from the figure, during January, 1973, it was not much geomagnetically disturbed. Only for 20^{st} and 28^{th} of January, the Kp values have exceeded 4+ and remained at that level for 3-6 hours.

2.1.2.2 Dst

Dst (Disturbance Storm Time) index is the mean of the variations on the horizontal component of the geomagnetic field measured by the near-equatorial geomagnetic observatories. As a consequence of measuring the horizontal components near equatorial, Dst index gives information about the Ring Current activity and the Equatorial Electrojet.

During the geomagnetically disturbed conditions, an enhancement on the ring current density occurs. As a consequence of the enhancement, as a response of the Earth System, the horizontal component of the geomagnetic field is modified. This signature can be seen on the Dst index.

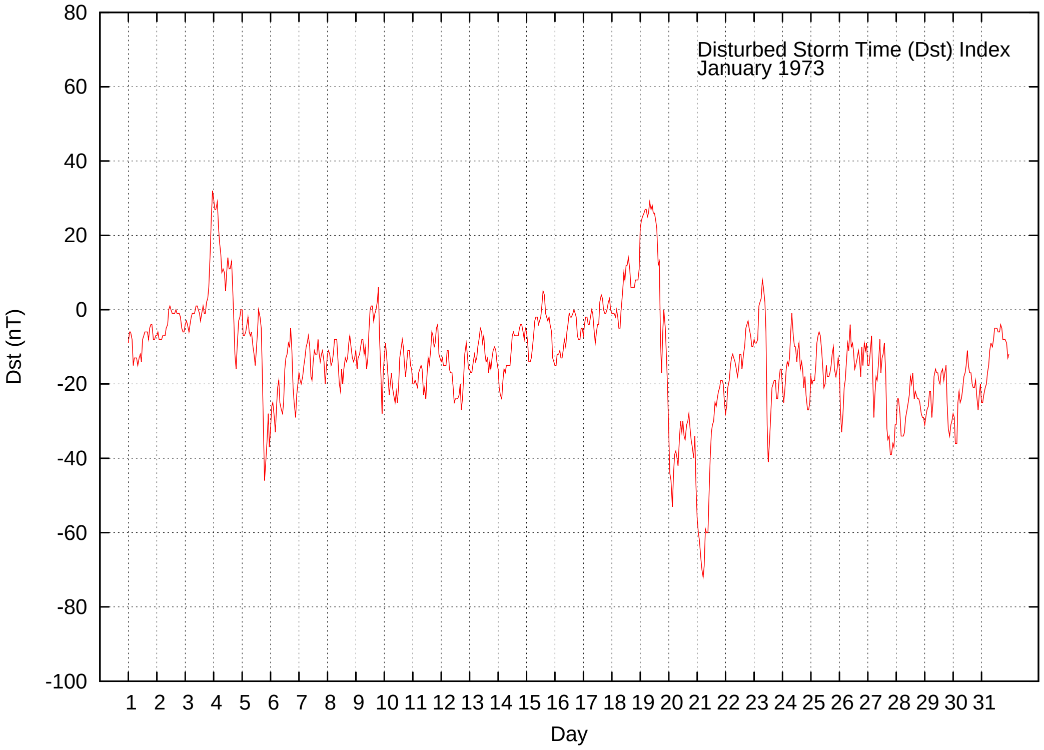

Figure 2.3: Disturbance Storm Time (Dst) index variation during January, 1973

Just after the geomagnetic storm, the accumulation of electrons and protons in the ring current region, the Dst index increases up to certain values. This period is named as the *sudden commencement*. After sudden commencement, the Earth System reacts in such a way to reduce the effect of the accumulation. Thus, after the sudden commencement, the value of the Dst index drops. This period is named as the main phase of the geomagnetic storm. After reaching the minimum value, Dst index starts recovering its original value before the geomagnetic storm, and this phase is called the recovery phase. For more detailed informatio, reader is referered to [8]. In Figure 2.3, the period January, 1973, was shown. The phenomena mentioned above can be easily seen from the figure.

2.1.3 F layer Critical Frequency, f_0F2

F layer critical frequency is the maximum frequency that the Ionospheric F layer can reflect. F layer critical frequency (in MHz) is measured with Vertical Ionosondes which are positioned in many locations, mostly in northern hemisphere. During disturbed conditions the measurements may not be achieved, thus there are data gaps in f_0F2 data, which are flagged as 9999. The Vertical Ionosonde stations of interest have been chosen to be Arkhangelsk, Kerguelen Islands and Slough. However, due to some data gaps in the Kerguelen Islands Ionosonde was excluded for the further analysis.

For the second step of the work, since only one station can be modeled at once, only one station, Arkhangelsk, was used for the modeling using Genetic Programming.

2.2 Data Organization

For the analysis, the data should be quantified, sorted and organized in such a way that the two methods of analysis could be applied with ease. Thus, the data were checked whether there were considerable amount of data gaps or not. In order not to impose any physical meaning by using statistical method (e.g. interpolation, cubic spline, etc) to fill up the data gaps synthetically, the available data were chosen from complete sets. All the data were retrieved from SPIDR of NGDC, and all files retrieved were in the same ASCII format.