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DAY TO DAY VARIABILITY OF IONOSPHERIC foF2

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Abstract

Large day-to-day variability in the ionospheric critical frequency (foF2) has been observed worldwide, regardless of geographic location, local time, season, solar flux, or magnetic activity. In this study, ionosonde data from nine stations spanning different latitudes are analyzed to investigate the characteristics of foF2 day-to-day variability. The analysis focuses on variations with respect to local time, seasonal changes, and solar and geomagnetic activity during the period from January 2006 to December 2007, corresponding to a low solar activity phase. The objective of this work is to improve understanding of the physical processes responsible for the observed variability in ionospheric parameters, with the aim of enhancing ionospheric modeling and prediction capabilities.

Introduction

The ionosphere, particularly the F2 layer, plays a vital role in radio wave propagation and space-based communication systems. The critical frequency foF2, directly linked to the peak electron density of the F2 region, serves as a fundamental parameter for understanding ionospheric behavior and its impact on technological applications such as HF communication, satellite navigation, and meteorological observations. Despite decades of research, the ionosphere continues to exhibit significant day-to-day variability in foF2, even under geomagnetically quiet conditions. This variability, often exceeding 20% during daytime and rising further at night or during solar maximum, cannot be fully explained by solar flux or geomagnetic activity alone, highlighting the complexity of ionospheric dynamics.

The present study, based on ionosonde data from nine stations during a low solar activity period (2006–2007), confirms that foF2 variability is a global phenomenon, independent of latitude, season, or geomagnetic conditions. These findings reinforce the need for improved ionospheric models that incorporate neutral composition dynamics, atmospheric coupling, and statistical frameworks to better capture short-term variability.

From a practical perspective, accurate characterization of foF2 variability is essential for enhancing prediction techniques and ensuring the reliability of communication and navigation systems. Scientifically, it provides deeper insight into solar–terrestrial interactions and the complex processes governing the upper atmosphere. Continued research into these mechanisms remains critical for advancing both theoretical understanding and operational applications.

Data and Method of Analysis:-

- Hourly value of foF_2 is obtained for the period January 2006 to December 2007 which is a low solar activity period from NGDC Ionospheric Digital Database of NGDC Space Physics interactive data resource(http://ngdc.noaa.gov/). To represent the day to day variability the standard deviation (σ) of hourly foF2 values from the monthly median value (x) is determined, from which the ratio of (σ/x%) in percentage is derived for each hour of each month of observation. This forms the basic parameter representing day-to-day variability of FoF2 .Variability parameter (σ/x%) is calculated for 09 stations separately for each day, month and seasons of the year. To understand the seasonal variation of foF_2 more clearly, we divided the year into three seasons' winter, summer and equinox. Variability of FoF2 during quiet days and disturbed days is also compared. For this purpose five very quiet days and five very disturbed days are considered. To study the effect of solar and magnetic disturbances on variability we consider the values of solar flux (10.7cm), K_P, A_P, AE, Rz and B_Z, indices which are collected from World Data Centre, Kyoto Japan.

Month-To-Month Variations of foF_2 :-

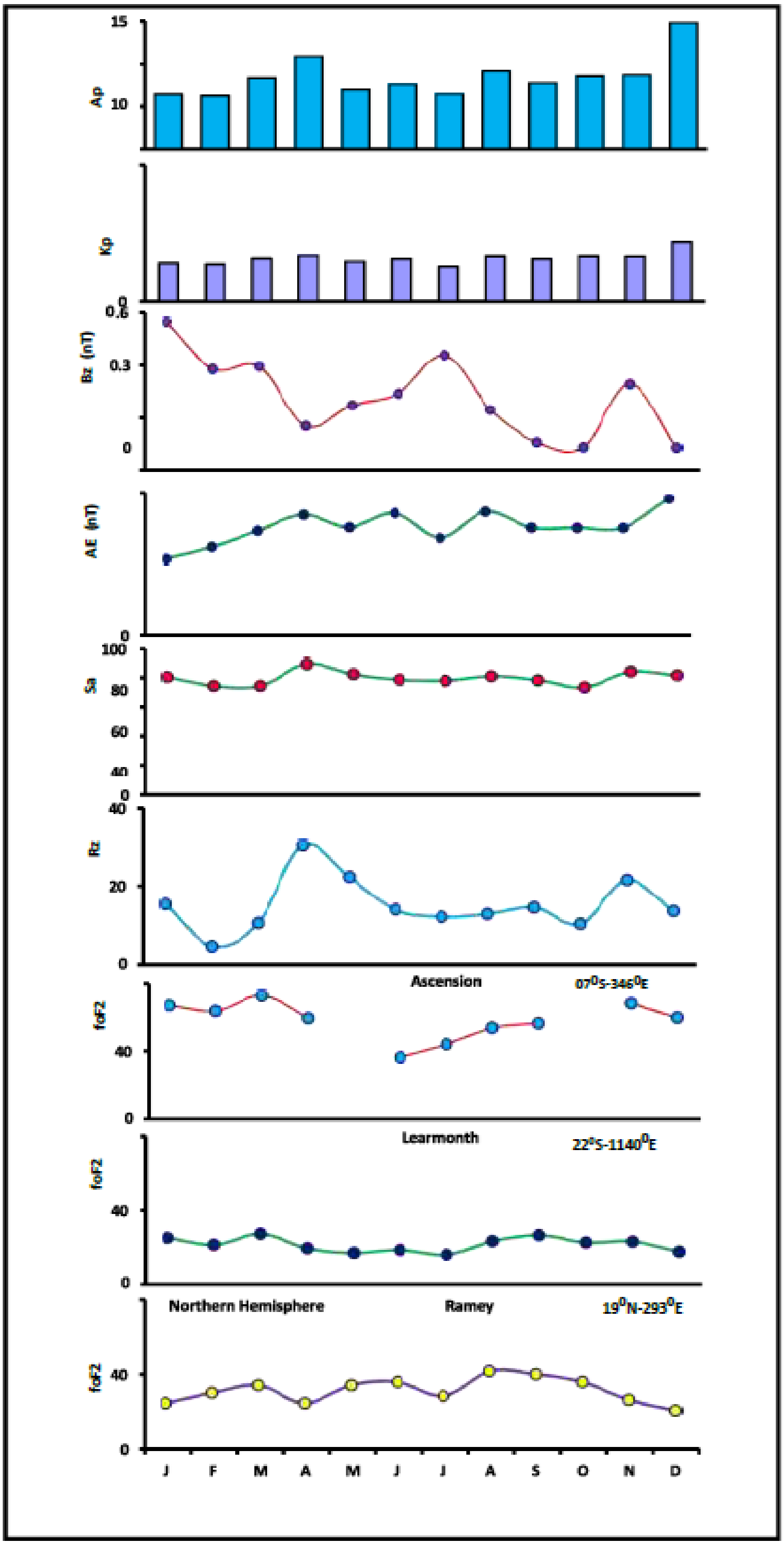
The month to month variations of variability parameter in FoF2 as well as for other solar geophysical parameter such as solar flux (Sa), sunspot number Rz, Kp, Ap, Bz and AE indices are represented in Figure 1 to 6 during the period of study from January 2006 to December 2007 for three low latitude stations (Ascension, Ramey and Learmonth), three mid latitude stations (Athens, Louisvale and Eglin) and three high latitude stations (Port_ Stanley, Chilton and College).

- **Low Latitude**: - The result presented in Figure 1 represented the variability parameter in foF2 and Sunspot number (Sa), AE and Rz for 2006. They are well correlated for Learmonth, but Ramey responses a little differently in nature and the variation for Ascension is not very clear due to the unavailability of missing data. During 2007 (Figure 2) variability of FoF_2 and all geomagnetic indices are well correlated for Learmonth, but Ascension stations do not show any regular behaviour.

- **Mid Latitude**: - The variations of foF_2 and other solar geophysical parameter for all three mid latitude stations (Athens, Louisvale and Eglin) are shown in Figure 3 and 4 .During 2006 (Figure 3) Eglin and Athens stations more or less respond in a similar pattern. During first three months foF_2 value of Louisvale is not available but for next 9 months values of foF_2 are well correlated .During 2007 (Figure 4) variability in foF_2 and other geophysical parameters are well correlated for Athens.

- **High Latitude**: - Figure 5 and 6 represent the variations of foF_2 and other geophysical parameter for all three high latitude stations (Port_ Stanley, Chilton and college).During 2006 (Figure 5) variability for Port_Stanley and Chilton stations is well correlated with sunspot number and solar flux. While during 2007 (Figure 6) the average behavior at Chilton stations do not respond in a regular pattern although Port_Stanley and College stations more or less in good correlation

LOW LATITUDE-2006



Monthly variations of A_p,K_p,B_z,AE index, Solar(10.7cm)Flux ,and Rz

FIGURE-1

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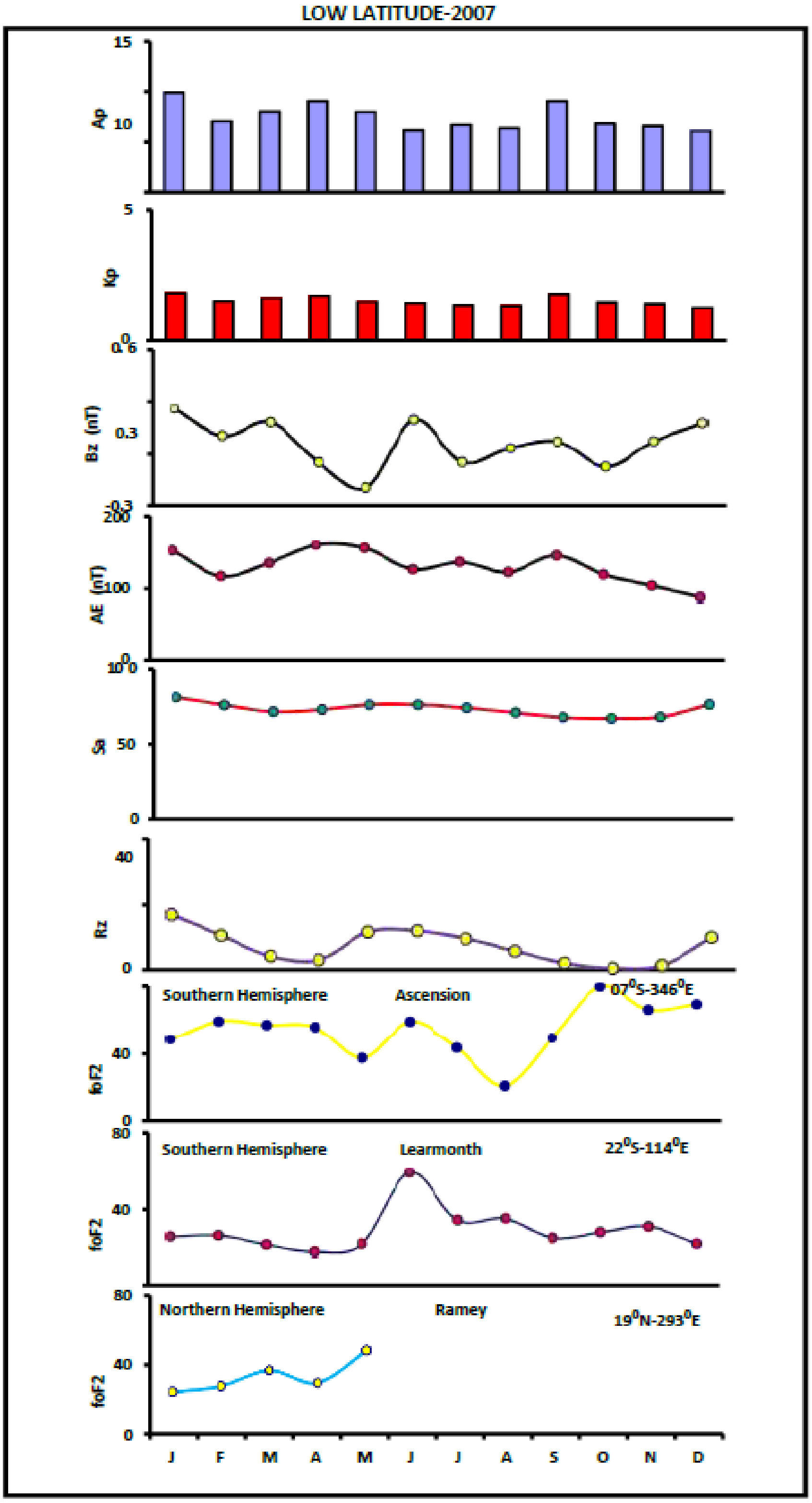
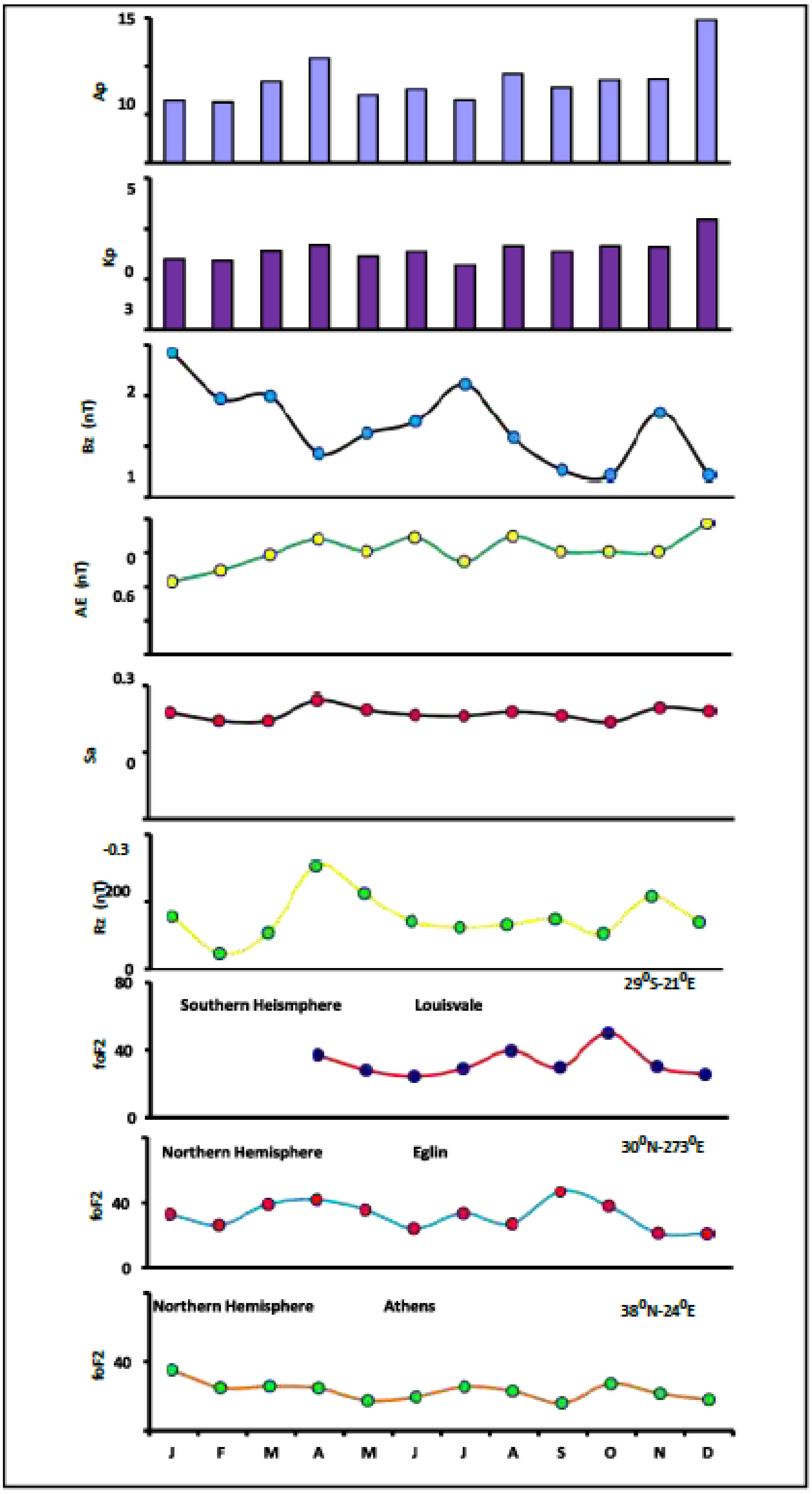


Monthly variations of Ap,Kp,Bz,AE index, Solar(10.7cm)Flux ,and Rz

FIGURE- 2

Mid LATITUDE-2006



Monthly variations of Ap,Kp,Bz,AE index, Solar(10.7cm)Flux ,and Rz
FIGURE-3

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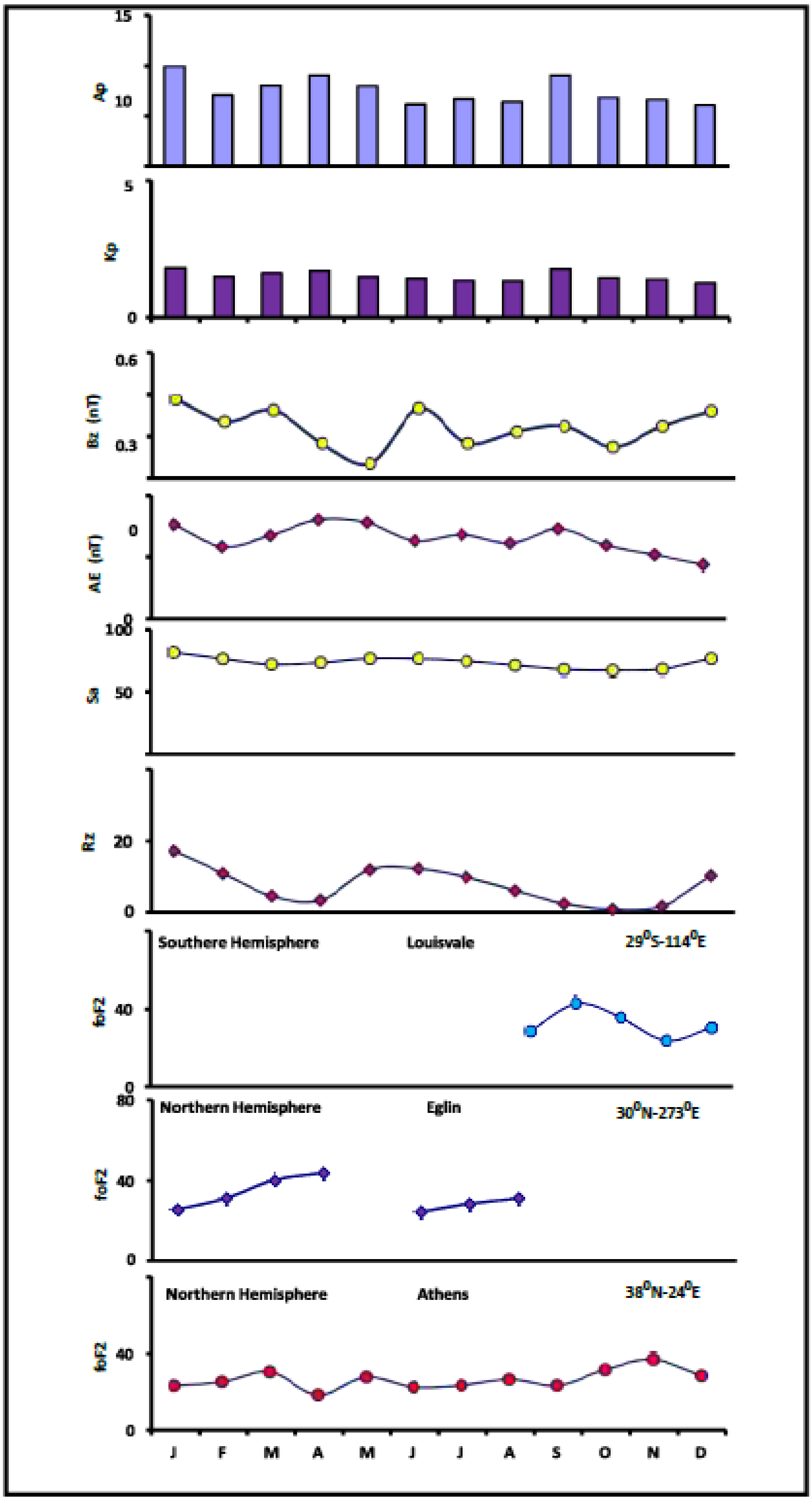
MID LATITUDE-2007



Monthly variations of Ap,Kp,,AE index, Solar(10.7cm)Flux ,and Rz ,Bz
FIGURE-4

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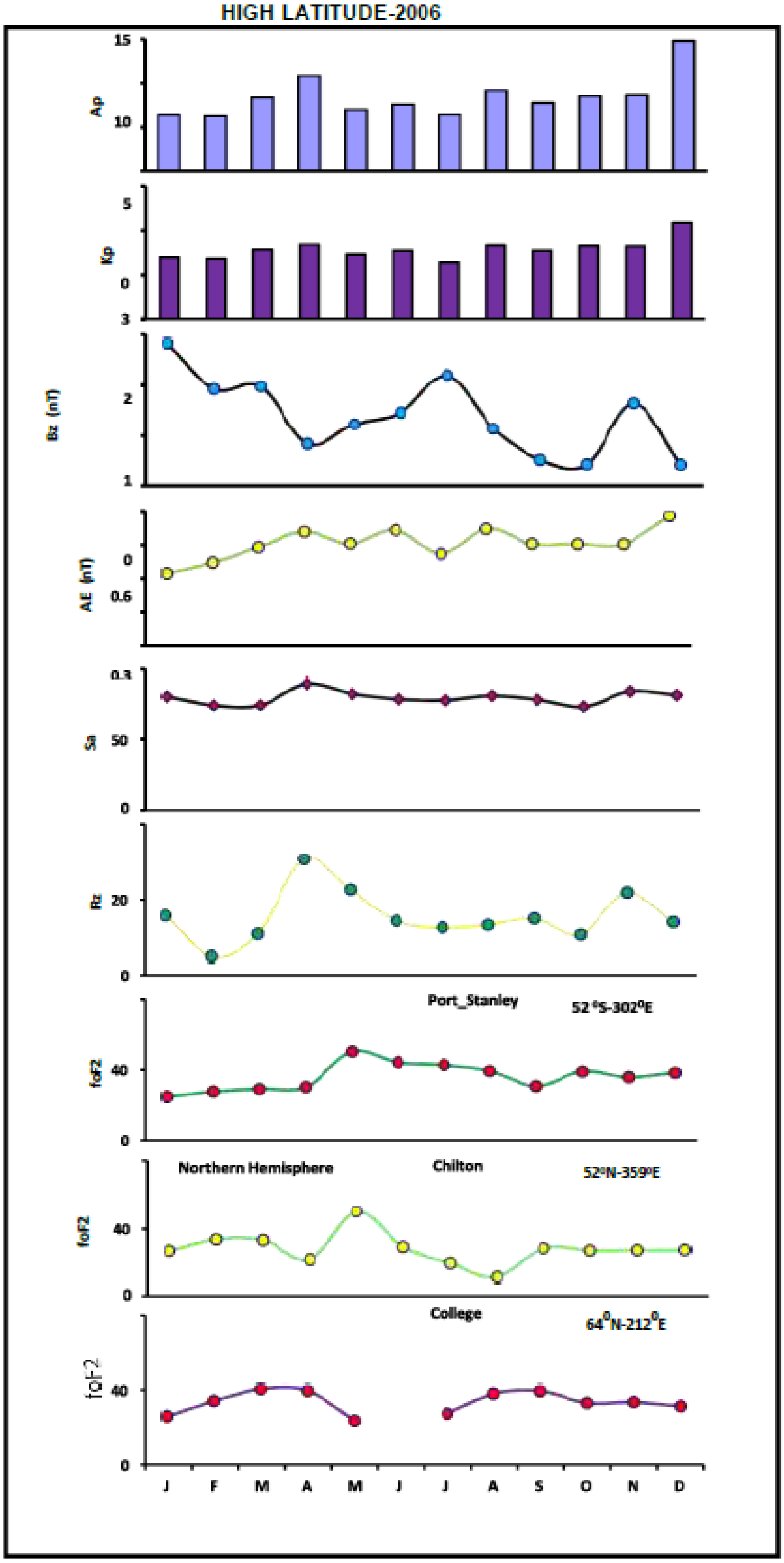
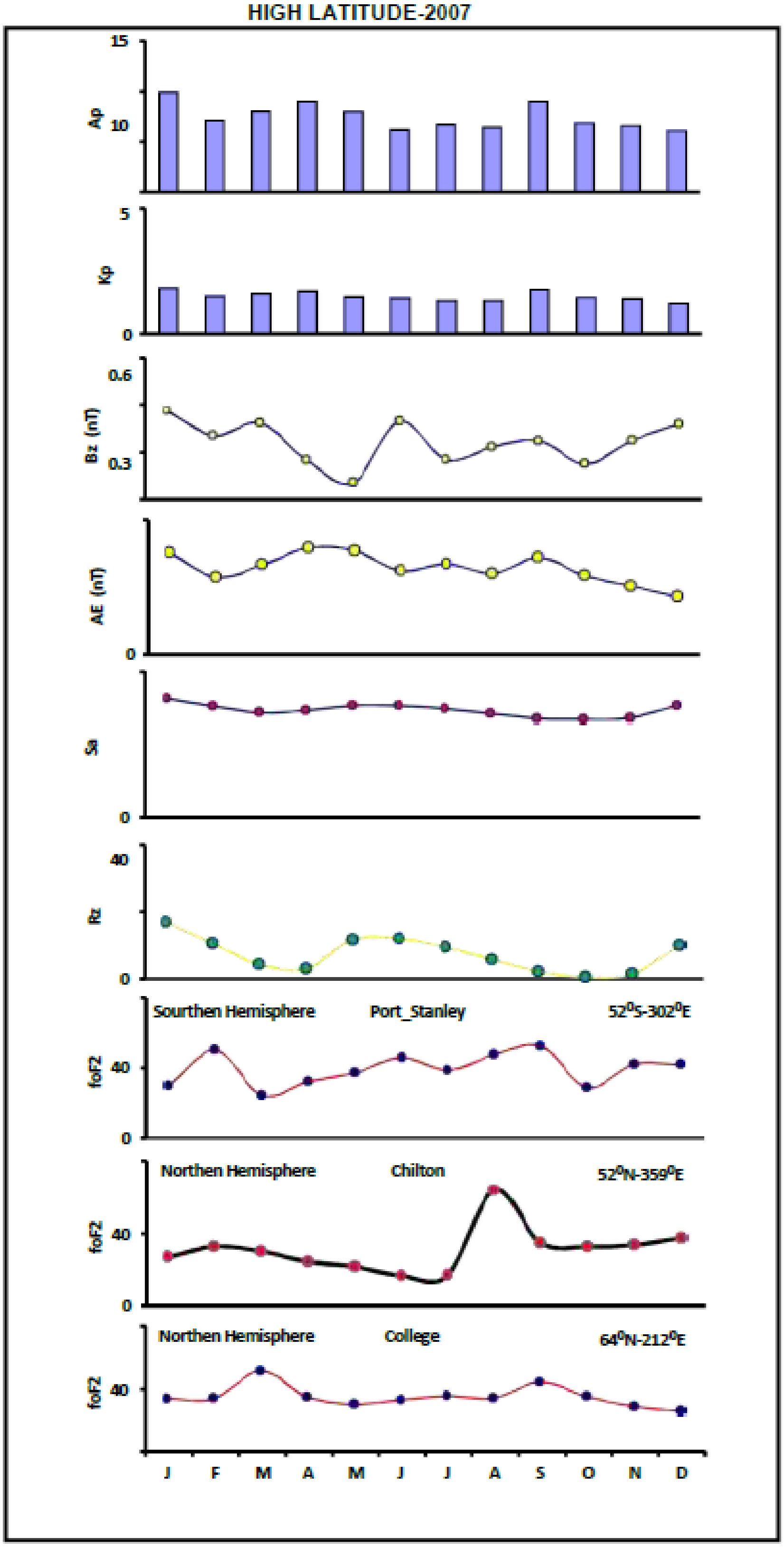


Monthly variations of Ap,Kp,Bz,AE index,
Solar(10.7cm)Flux ,and Rz FIGURE-5



Monthly variations of Ap,Kp,Bz,AE index, Solar(10.7cm)Flux ,and Rz
FIGURE-6