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MAGNETIC AND IONOSPHERIC STORMS IN İSTANBUL: AN OBSERVATIONAL REVIEW

İstanbul'da İyonesfer ve Manyetik Fırtınalar: Gözlemsel bir Bakış

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ABSTRACT

The geophysical behavior of the Earth ionosphere during Storm Sudden Commencement (SSC) and Magnetic Storms (MS) has been investigated using the data of Istanbul (41°N; 29°E) and the other observation sites with Mc Ilwain Magnetic Dipole Shell Parameter, $L \cong 1.6$. As a result of the study, characteristic features have been discovered during the solar activity period of 1964-1970 era, except through the non-flare-associated storms, thereout 97 Ionospheric Storms (IS) with Sudden Commencements (SC) assigned from the other flare effects, those in which have 3-hourly magnetic activity index value $4 \leq Kp \leq 7$. When regarding the interactions between ISs and MSs, during the SC, without any classification overall an increase of maximum electron concentration of F_2 layer (NmF_2) in the ionosphere followed by deviations of critical frequency of F_2 layer (f_0F_2) have been observed for all ISs. The local data used in this paper are hourly values based on ionograms and magnetograms measured in İstanbul, form the European Coast İstanbul Ionospheric Research Station (IIAI, 41°02'N; 28°97' E) and from the Asian, Coast İstanbul Kandilli Observatory (IKR, 41°03'N; 29°04'E) respectively. The first result is the frequency deviation obtained quantitatively 3-4 % Δf_0F_2 which shows an increase comparing monthly medians accompanying SSCs with Kp increases both in the local magnetic field H component and ionospheric peak height (hp) or maximum height (hm) variations. Upliftings are observed

ÖZET

Bu çalışmada, enlemi 41°K, boylamı 29°D olan İstanbul kayıtları ile Mc Ilwain Manyetik Dipol Kabuk Parametresi L= 1.6 olan diğer gözlem noktalarındaki veriler de kullanılarak, SC (Ani Başlangıçlı) iyonosfer fırtınalarının, jeomanyetik SSC (Fırtına Ani Başlangıçları) ile ilişkili davranışları incelenmiştir.

Amaç, Güneşin periyodik etkinliğinin 1964-70 döneminde gösterdiği olağanüstü fışkırmalarla manyetosferde gelişen ve yermanyetik alanını etkileyen SSC fırtınalarının yukarı atmosferin iyon yoğunluğunu sarsan ve düzensizliklere yolaçan yerel etkilerin belirlenmesidir. Normal Güneş fışkırmalarından etkilenmeyen SSC türü değişimler arasından 3 saatlik manyetik etkinlik katsayısı $4 \leq Kp \leq 7$ olan 97 adet SC fırtınanın istatistik analizi yapılırken, ilk önce fırtınaların tümü hiçbir sınıflandırma yapılmaksızın incelenmişlerdir. Ani fırtına başlangıç fazlarının, manyetik fırtına ile iyonosfer fırtınası arasındaki ilişkiyi arttırarak yukarı atmosferin bütün bölgelerini etkilemiş oldukları görülmüştür. Bu etkiler, teknikte en çok kullanılan F_2-tabakasının kritik frekansıyla ölçülmüş ve iyonosferin maksimum elektron yoğunluğu ile yüksekliği üzerinde SC ile azalan (negatif) ve artan (pozitif) fırtına fazları şeklinde çizilmişlerdir. Aynı başlangıç saatlerine sahip fırtına verileri "İstanbul İyonosfer Araştırma İstasyonu" (İİAİ: 41°02°K; 28°97°D) ve "İstanbul Kandilli Rasathanesi" (İKR: 41°03°K; 29°04'D) kayıtlarından seçilmişlerdir. İİAİ yerel iyonogramları (kritik frekans ve yükseklik diagramları) ile İKR'nin yerel manyetogramlarında, yermanyetik alanının yatay bileşeni H'nın SC'li tüm fırtınaları çakıştırıldığında İstanbul için ortalama % 3-4 MHz'lik bir frekans artışı saptanmıştır. Aylık mediyanlara kıyasla gözlenen bu artış, Kp değerleri büyük olan ve SSC'lerle tetiklenen H bileşenindeki yerel değişimlerle paralellik gösterdiği gibi, aynı zamanda, iyonosferin tepe noktasının yoğunlaştığı yüksekliği de beraberinde sürüklediği görülmüştür. İyonosferin F-tabakasındaki bu yükseklik hareketinin incelenmesi için fırtınalar gruplara ayrıldıklarında, yazları akşam

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without delay in the evenings of the summer and also during winter days but with a delay of 5-6 hours, while collapses are observed without delay in the winter nights and also during the summer days with retardations of 3-4 hours. Considering variations in two groups, March to August as summerlike, September to February as winterlike events, daytime and nighttime behaviours are different from each other because of the effect of sudden particle transportation and slow electron production respectively during night and day.

saatlerinde H ile eşzamanlı bir artışa karşın, kışları gündüz saatlerinde 5 ile 6 saate varan bir zaman gecikmesinden sonra böyle bir frekans artışı gözlenmiştir. Öte yandan iyonosferin alçalması, kışları gece saatlerinde H azalması ile eşzamanlı olurken, yazları gündüz saatlerinde 3 ile 4 saatlik bir gecikme göstermektedir.

Sonuçları bir genellemeye götürmek için, gece ve gündüz olgu benzerliklerden Mart-Ağustos arası süre yazbenzeri, Ekim-Şubat arası süre kışbenzeri fırtınalar olarak iki grupta tanımlanmış ve gündüz vakti fırtınaların ani parçacık taşınması etkisinde kaldıkları, gece vakti fırtınalarının ise elektron üretimi eksilmesi etkisinde oldukları anlaşılmıştır.

INTRODUCTION

The existence of ionosphere had presented itself more sound when Marconi attempted to apply a high frequency (HF) transatlantic long distance communication (LDC) between England and USA in 1901. Whilst, remarking solar storms which often disrupt radiocommunications and produce auroras, could be seen the needle of a compass exhibited irregular deviations in its direction less than a degree, as recognized firstly Celsius and Hiorter in 1741. Then, magnetic storm (MS) concept was first introduced by von Humboldt in 1808 and after a while of three decades Gauss measured the geomagnetic field (GF). Later, during the war years, over LDCs, the new geomagnetic storm (GS) theory contributed (Chapman and Bartels 1940, Ferraro et al 1951). Since then the extend and nature of the interconnections between geomagnetic variations and ionospheric disturbances have been under consideration due to their vital importance and mysterious solar dependence of via magnetosphere coupling where reconnection still is under consistent observations (Kamide 1988).

In this paper some of the previously reported results are also discussed and compared not only with those obtained from the ground based ionosoundes but also from the electron density experiment on board satellites and rockets as well. Tulunay and Sayers (1971) report on anticorrelation of Kp increases that decreases L values for the through of ionization minimum moving to lower latitudes in the northern hemisphere around noon time using satellite data.

The aim of this observational review paper is to contribute to the state of recent ionospheric predictions and to accentuate the importance of them (Davies 1981, Titheridge 1988, Fox and McNamara 1988, Rawer and Bilitza 1989) knowing that radio propagations are under the control of latest forecastings and as well as local ionospheric observations.

SOLAR TERRESTRIAL DEPENDENCE OF GEOMAGNETIC STORMS

GSs appear as a result of the Ring Current (RC) strong enhancement, deep within the magnetosphere, in the regions where the Earth Magnetic Field (MF) does not drastically depart from that of a dipole. There lies the Van Allen Radiation Belt (RB), consisting of Energetic Particles (EP) like electrons, protons, alphas, and a very small fraction of heavier ions spiraling from north to south and back along the field lines in quasi-periodic orbits while encircling the Earth as a belt in a certainty of a range variation within 0.8-1.0 RE up to 4.0-4.5 RE (RE ≅ 6371.4 km).

However, Ionospheric Storm (IS) is the effect of a MS obviously causing an increase or decrease on the electron density (Ne) and real height of the F-Region (hF) over D-region. But, the duration of the GS depends on the level of geomagnetic activity and its solar origin. Possibly some solar wind shocks not to be followed by a typical GS if those time intervals are not associated with the enhanced southward Interplanetary Magnetic Field (IMF). Geomagnetic source indices Am, Ap, Kp, or three-dimensional components of IMF, are related with solar wind parameters, ϵ, vBz (Meloni et al 1982). AE (Auroral Electrojet Activity) or i.e. Bz, that progressively effects not only the horizontal component of the main field (H) but also the time function of the energy injection into the ionosphere or replenishment of flux tubes and also rising and falling responses of field disturbance due to the nature of the RCs circulating the Earth's outer equatorial plane asymmetrically during nighttime and daytime.

Shah defined a percentage asymmetry as

100 (AN-As) [(AN+As) / 2]

between the activity indices of northern (AN) and southern (As) hemispheres respectively (Shah et al 1984). The influence of IMF on the ionospheric F-region causes a diurnal variation with minimum in the morning (≅ 11 UT) and with a maximum in the evening (≅ 23 UT) times. Moreover, seasonal variation that should favor energy input by the control of IMF-Bz component during the Autumn and also should inhibit energy input by the IMF +Bz component during the spring season (Bremer 1988).

As a measure of solar radiation, Kp is one of the two most commonly used indices combining the geomagnetic activity observed at certain standard midlatitude stations, while the other is AE which uses auroral zone stations and therefore responds mostly to auroral current systems.

For predicting the recond size and maximum amplitude of the sunspot cycle it was reported that most reliable is one that uses the minimum annual averages of sunspot number, R(min) and the Ap index. Because Ap(min) has a correlation coefficient of 0.997 with a standart error of only ± 3.9 (Wilson 1988, p. 773). When storm-time Disturbance (Dst) index was designed by Sugiura in 1964 as a measure of magnetospheric RCs of MSs, high latitude and equatorial stations are avoided to minimize the effects of auroral and equatorial electrojet.

It must be pointed out that Faraday induction law applies to the RC in the plasmapause region which generates two types of ionospheric variations in the upper atmosphere named as (i)-positive IS or (ii)-negative IS in which both are followed with two opposite phases (Agopyan 1982) vs GSs having three well known (i-initial, ii-main and iii-recovery) phases (Agopyan 1986, Fig. 1 & Fig. 2). For the generation and establishment of such an IS possessing negative (-) and positive phases (+p), the necessary time-constant of the initial phase could be a quarter of a daytime period (Tanaka, 1978). And one has to take into consideration that the first phase or the commencement type of the IS will firstly depend on its own geophysical conditions where the required rise time period ($\iota \sim 300$ sec or less than 1-6 min) of such a magnetospheric signal known as SC or sudden impulse (SI) can follow a SSC.

It should be kept in mind that after a volcano eruption, hurricane, strong earthquake registered 5.5 or more on the Richter scale (Kelley 1985) or a nuclear detonation using at least 1 Megaton of Hydrogene, the internal energy of the Earth gravity field oscillates the ionosphere around the Earths MF lines. The increased atmospheric temperature and compositions along the E-fields may vary 8 h or more. The triggering mechanism is first specified by the local anomaly or crustal parameteres of the station, local geology, tectonic structure, seismo-ionospheric relationship and radioemission frequency of seismic activity, E-field, H-field, local time (LT), height and dipole coordinates of the source, than the onset of the MS, current season and solar epoch etc. But, during magnetically quiet conditions, from the published data on experiments of a seismic radio emission (Gokhberg et al 1982) before a seismic shock an effective electromagnetic radiation power of a seismic dipole emitter can be calculated using the known formula of the radiowave propagation theory (Alpert 1960).

GEOMAGNETIC MODIFICATION

Changes in critical frequency of F2 layer (foF2) of the Ionosphere are depended not only to the sunspot numbers and local daily variations but also to the ions being transported from the equator along the GF lines, illustrated thirty years ago (Rastogi 1960). Another reasonable explanation to the fact that the electron displacement or ionic flow caused by the variations in the field which is an immediate result of the SSC, will produce changes on electron density with a retardation of several hours. By use of low latitude ionosounder data selected through the same solar activity period of 1964-1970 era, it was found (Skinner and Kelleher 1971) that diffusion might be the responsible cause due to ionospheric irregularities transported down to GF lines. Since the GF lines would give assignment to the locality of an atmospheric research station or a geomagnetic observatory using only L Magnetic Shell Parameter (McIlwain, 1961), it happened to be a common confidence for some workers (Laval et al 1969, and Young et al 1980), that it is more suitable to define an observatory site with double coordinates instead of triples. Hence Mc Ilwain magnetic dipol shell parameter "L" defined as

$$L = \frac{RE}{Re\ Cos^2\lambda}$$

where RE is the Earth's radius, Re is the distance between the geocentre and the point, a MF line crosses the equatorial plane, while λ denotes the magnetic latitude angle of the observatory.

So accordingly L value of İstanbul observatory is $L \cong 1.55$, a fact indicating that the observed ionospheric and GF changes of this site SSC in general should rather have equatorial characteristics (Agopyan 1986) and experimental responses are being in agreement with latitudinal foF2 variations (Bremer 1988, Fig. 8).

DYNAMICS AND STATISTICS FOR IONOSPHERIC STORM ANALYSIS

It could be noted that most of observed winter storms show positive enhancements (He^+dominance), whereas, summer and equinox depressions often follow (H^+dominance) short lived enhancements (Bailey and Sellek, 1988). Consequently, it is the negative response of the IS that causes the major LDC problems i.e. 10m-600m HF waves (Wrenn and Rodger 1989). The reason of such a dynamical disturbance and the physical mechanism of its occurrence is believed to be due to the sun flares, the enhanced solar wind streams emanating from magnetically open features in the corona known as coronal holes. As the stream sweeps over the Earth, electric currents flowing in the magnetosphere and ionosphere are modified, yielding both MSs and ISs, and are recurrent having physical mechanisms accessible to storm transit time scales by correlative analysis minutely (≅ 1 min-10 min-15 min-30 min), hourly (≅ 1h-2h-3h), daily (≅ 1d-7d), synodically (≅ 7d-12d-27d-35d), seasonally (≅ 1-6-12 months) and cyclically (≅ 5-11-14-22 years) solar and geomagnetic activity dependent characteristics in quasi logarithmic averaging intervals (Baker 1986). However, solar flare-induced storms also can be noted here that are being weak but lasting a few days longer because of the time taken for the stream to pass over Earth, and the ionosphere becomes opaque, screening out the synchrotron emission from the most abundant of cosmic electrons, for the long wavelengths greater than 30 meters (Welch 1988).

GEOMAGNETIC TRIGGERING MECHANISM BY SI, SI OR SSC.

Geomagnetic sudden impulse (ŞI) can be accepted as a sharp change observed in the ÇF whose onset (Ustaoglu 1988) is recorded within 1 min all over the world. A positive SI is characterized by a global increase in the H component of the GF while a negative SI is same by a decrease in the H component of the GF. The shape of SI depend on latitude and LT with a rise and fall time from 1 min to several minutes and the magnitude of it rarely exceeds 50 nT. When SI precedes during high geomagnetic activity interval positively, becomes SSC or SC.

After a SSC, ISs that form together all over the world was first observed by Hafstad and Tuve, in 1929. In 1931, Chapman and Ferrora noticed that SSC is the signature of charged particle stream of the sun having equal number of positive and negatively charged particles being hot enough to yield high electric conductivity. As the stream propagates toward the Earth, an electric current is included on the surface of this highly conductive plasma to shield its interior from the GF. But the storm time disturbance of the field (Dat) meaning the average time variation of H, D and Z components of GF over a large number of GSs shows dissimilarities for different latitudes and sometimes lasts after a SI presumably without causing any stormlike disturbance (Vestine 1960, p.41). Matsushita reports first IS patterns in maximum electron density of F2 layer (NmF2) showing certain global features and characteristical differences in different latitudes such as foF2 values, for middle latitudes, having an appreciable increase in the beginning phase of Dat (Matsushita 1959). Since 1935, Appleton and Ingram, Kirby and many other researchers found quantitative NmF2 of the ionosphere increase or decreases after the SC or SI and during the main and development phases of MSs. But, during "STRONG" or "SEVERE" MSs, in equatorial observatories, Berkner claimed first that there in Huancayo and Watheroo seen sudden and intense depressions in NmF2 densities within the first hour following the SC onset, concurrently observed increases in virtual height of F-region (h'F) values and also some spread in the distance between F1 and F2 layer peaks of the ionosphere. Like Appleton and Piggot (1952), Martyn (1953), Skinner and Wright (1955), Maeda and Sato (1959) and many different researchers in the same decade of 50's, all report about some observations indicating that ISs have less marked onsets than those of SSC's, while Lewis and McInstosh (Thomas and Venables 1966) suggest that the extreme changes in NmF2 values happen to occur completely independent of, and begin several hours late after the main phase of GS.

MODERN STUDIES

Aarons and Martin (1975) found that during a MS there was a negative correlation of scintillation and magnetic indice for the stations having L ≅ 1.6. Davies (1980) reviewed the experimental results of ATS-6 geostationary satellite and Klobuchar et al (1978) summarized diminishment of protonospheric electron content. Since plasma flow between the magnetosphere and the ionosphere contributes to the negative storm (Leitinger et al 1987 and Klobuchar 1988) at higher latitudes (Shunk et al 1976), than progressively moves to middle and low latitudes (Mendillo 1986) were most comprehensive studies by experimental results published lately forming and originating ISs (Mayer et al., 1978 and Prolss, 1980) in midlatitudes, storms with 35 hours recovery time constant and having larger and earlier positive storm phase (p) are dominant in southern hemisphere while negative storm effects larger in the northern hemisphere (Shah et al 1984, Buonsanto 1988) after a first positive phase (+p) or negative phase (-p). And the size of the +p is proportional to the ap (polar activity) size in winter not in summer except larger storms and the mean size of the -p both in summer except larger storms and the mean size of the -p both in summer and in winter does not increase for the GSs with Kp > 6, but starts several hours earlier by total electron content (TEC) being proportional to the Oxygen and Nitrogen ration [O] / ([N_2]+23 [O_2]) at peak height of the F region (hpF).

Storms with a SC during sunlit hours produce an increase of about 30 % in TEC at both 35°S and 35°N latitudes but in summer this is followed by a rapid overnight decay and a large negative effect on the second day. The winter TEC results for south also decay rapidly near midnight. At north, however, the positive effect is sustained through the night and to about noon of the next day. This difference probably results from the large westward winds which are expected at night about 5 hours after a period of strong magnetic activity. At lower latitudes (20°N) records or measurements show an appreciable -p only for summer conditions while +p effects are larger in the southern hemisphere (20°S) lasting for about 3 days and 1 day at northern, and TEC is larger at 20°N (Titheridge and Buonsanto 1988).

NEGATIVE STORMS AND INTERHEMISPHERIC WINDS

Changes in thermospheric circulation and wind induced diffusion of the neutral constituents act to decrease O/N_2 and O/O_2 at middle and high latitudes and to increase these ratios or keep them fairly constant at low latitudes (Mayr and Volland 1973). During storms the enhanced equatorward winds will oppose summer to winter circulation in the winter hemisphere, but add to it in the summer hemisphere. Thus the area of decreased O/N_2 ratio (or enhanced N_2/O) extends to lower latitudes in summer and sharp latitudinal gradients of N_2/O occur in winter.

The net influx of plasma measurements showed that prominent plasma interchange between the ionosphere and plasmasphere constitute an interhemispheric coupling at low latitudes (Bailey and Sellek 1988) and flux tubes of higher latitude $L \cong 1.5$ values become able to act as a plasma reservoir, filled at one daytime and emptied during night. It was confirmed (Mendillo 1986) that interchange of plasma depends on thermal and dynamical forces at both ends of flux tube in the E-region in which during solstice conditions interhemispheric transport is directed from summer hemisphere to the winter hemisphere.

REFILLING PROCESS OF PROTONOSPHERIC TUBES

Recently Song (1988) showed that after refilling method of Lemaire Kp statistically separates situation in which GEOS satellite crosses the plasmapause and therefore measures plasma for which there is no loss by convection over 24 hour period. From situations, in which it does not plasma can be determined very accurately, further improvement in the theory could be made by better ionospheric temperature and composition measurements at the exobase and their variation with magnetic activity. This parameters are fundamental for evaluating the upward flux of the plasmasphere.

Protonospheric flux is the main plasma source in the F_2-layer during substorms and recombination rate is the sink on the midlatitude night time F_2-layer to be determined by the temperature of the neutral atmosphere of E-fields and neutral winds. As many authors reported that enhancements have a maximum near I=45° due to winds and near 55° geomagnetic latitude with the probability of its appearance decreases towards lower or higher latitudes accompanying atmospheric gravity wave generation during negative ISs (Cander et al 1988). But, because of core field the dipolar variation will dominate solar cyclic and synodic effects due to the selected small $Kp \leq 4$ values for selected method of analysis. The results may depend not only to the external component of the GF but also to its internal anomaly component, method of statistical analysis, averaging and other cases as well.

PROTONOSPHERIC RESERVOIR AND IONIC TRANSPORTATION

The plasmasphere, which is known as the region remaining between plasmapause and ionosphere is filled with low energy plasma. Because of low energy plasma originating in the weakly ionized upper atmosphere this can be considered as an extension of the ionosphere along MF lines extending out to 4 RE (25 thousand km) in the equatorial plane. Therefore there are transporting of ions from ionospnere $O^+ + H ==> O + H^+$ to protonosphere into plasmasphere during daytime, and at night $H^+ + O ==> H + O^+$ from protonosphere to ionosphere, a flow out, increases night side neutral hydrogen concentrations. The balance of accumulation, or depletion of plasma flows in the field tube is not expected when there is a MS, because E-fields convect plasma across field lines causing delay in balance of day to night, $H + O^+ <==> H^+ + O$, pointed out by Dungey (1955) to be a source and sink of hydrogen ions in the thermosphere. In 1978 Tinsley adds that in the absence of source and sinks, the altitude profile of H^+ ions in the presence of O^+ ions (Tinsley et al 1986). Meanwhile considering MSs and horizontal flow of the atmosphere, which would also effect the chemistry by the loss of H^+ ions from the plasmasphere (Bailey 1988) can be outward into the tail, and also very significant during the periods of high magnetic activity. Vertical stratification of the normal ionosphere does not consider horizontal movements and the contribution of electron temperature (Te), electron density (Ne) and ionic density (Ni) position the drift measurements. From Atmospheric Explorer satellite it is known that, ionospheric layer thickness and its accuracy is depending on recent corrections to reference parameters (like solar activity and gravity) for mapping, and profiling of anomalies, for topside, peak and bottomside shapes of the ionosphere, by IRI (International Reference Ionosphere) computer program (Bilitza 1988), Polan (Polynomial Analysis) computer program (Titheridge 1988) and many others for valley to peak calibration for topside and bottomside additional parameters. With the echo power measurements reflected from the peak of F-layer at 200 km during night time, where the temperatures of ions and electrons are equal Te = Ti = T = 2000°K, but from 700 km up to 1300 km T ≅ 5000°K temperatures change to 16000°K has been measured by Sato (Buonsanto 1988).

SAR ARCS

Stable auroral red (SAR) Arcs are known auroras to occur equatorward of the oval at mid latitudes and visible in conjunction with major GSs (Cornwall et al 1971). From a pass of satellite-borne spectrometer, massive ion composition measured with a limited relative detectability (Shelley et al 1972) and approximately several hours positively correlated with large flux densities of heavy ions, to be related to higher Kp values, suggests that during GSs a low altitude acceleration mechanism is operative. In the altitude range where O^+ ion is the dominant ion species, ambient ionospheric ions accelerate to energies of the order of 10keV. Moreover this ions could make a significant contribution to the extraterrestrial RC and may even be responsible for the production of low altitude SAR arcs. Concluding on the source of night side aurorar oval precipitation which bases on energetic ion mass composition results, having the plasmasheet as populated by solar wind particles. Also, during large GSs the ionospheric ions may be accelerated to compete with the solar wind as an energetic ion source. So, first Rodger and Aarons (1988) suggested that the midlatitude regions are invaded by high latitude processes and responsible to the formation of F-region irregularities during geomagnetically active periods. This may be achieved in one of two ways, through negative storm effects, or through the occurence of SAR arcs. The energy source for SAR arcs is probably the O^+ ion component of the RC having the close relationship between Dst and occurence of midlatitude irregularities.

WHISTLER, AIRGLOW OR NIGHTGLOW

Whistlers are waves originated from lightening discharges in the atmosphere and propagate in a plasma wave mode that can also conduct very low frequency (VLF; 3-30Khz) radio transmissions through the propagation of low latittude whistlers by means of ray tracing is investigated in (Hasegawa and Hyakawa 1980) detail showing non-ducted propagation of the whistlers and predicted downcoming rays on 20°-24°N. Nigh-time whistlers at very low latitudes show inevitable requirement of ray tracing computations (Baixian et al 1985) to understand why equatorial anomaly tends to disappear during " severe" GSs and appear airglow and nightglow at lower middle latitudes. During GSs magnetospheric convection pattern expandes equatorward, at times reaching middle latitudes produces westward ion drifts at the early evening hours.

Previous thermospheric empirical model based on temperature, density and composition data gave values smaller than the measured values by about 250° K, while the difference was about 200°K with modified MSIS-86 empirical model including only additional LT variations in the magnetic activity effect. Also neutral temperatures determined from ground-based optical techniques using Fabry- Perrot interferometers considerably differ from MSIS models (Murty and Kim 1988). Sahai et al (1988) reported that no 0^+ ion dissociation radiation intensity enhancements occur in the OI 7774 A° (results from radiative recombination of O^+ ion) emission due to energetic particle precipitation were evident in southern low latitudes in contrast to middle latitudes nightglow emissions.

During "SEVERE" MSs, the observed OI 7774 A° intensity variations followed the changes of $(f_oF_2)^2$, suggesting radiative recombination as the main excitation mechanism. But F-region nightglow emissions at OI 6300 A° (Red lines of wavelengths with 1.96eV), result from dissociative recombination of diatomic O^+_2 ions, with a small contribution from ion-ion recombination (Tinsley et al 1986) have extensively reviewed the low-latitude aurora and stormtime current systems, that intensity enhancement due to energetic particle precipitation is associated with a large Kp value and a large decrease in Dst. Nightglow emissions identify the optical signature of MS effects on the ionospheric F-region.

Tanaka (1986) suggests that vertical ionospheric plasma oscillations are associated with magnetospheric substorm E-fields penetrating to low latitudes and thermospheric neutral winds are due to high latitude thermospheric heatings (Sahai et al 1988).

RADIATION BELT ZONE DURING GSs

Radiation Belt that survives is in spite of the existence of GF and thus shows a long term secular variation. But there are also short term field variations, which are reversible caused by the temporary existence of a RC in the outer radiation zone, which such process of a RCs are formed for periods of days during GSs. The current is due to the azimuthal drift of low energy protons and electrons which are added or accelerated during GSs. The general effect of this field perturbation on trapped particles was discussed by Dessler and Karplus (1961).

During and after GSs large additions of energetic electrons occur in the outer radiation zone. As it happened during the September 1966 GS, and also a radial diffusion current directed inward as far as the inner zone. Thus important amount of electron additions were made to the inner zone, particularly in the energy range of a few hundred keV. Tomassian et al (1972) made a detailed study of this event in the crucial L range $1.7 < L < 2.8$ in order to extract a value for the diffusion coefficient required to produce such diffusion.

According to the results of many researchers, the gate between the inner and outer zone of the radiation belt was closed from the time of the Starfish detonation in July 1962 until the additions made in September 1966 (Pfitzer and Winckler 1968 and Tomassian et al 1972) suggested that the gate must be opened only after important MSs, and than closed by the depletion of electrons in the so-called region by pitch angle diffusion.

DATA ANALYSIS AND RESULTS OVER İSTANBUL

We tried on interconnections of GF with the ionosphere where the local conditions may have considerable effects over İstanbul. Local coordinates are 41°N; 29°E, and geomagnetic coordinates are 39°N (colatitude ≅ 51°N); 108°E and L ≅ 1.6. Statistical analysis have been realized to determine characteristic storm patterns knowing that major interval of high solar activity being challenging is considerably different from those of solar minima or relatively quiet times reports Kamide (1988). Due to eastward E-field generated drifts may cause an upward and poleward neutral wind such that ionization moves horizontally at a fixed height. This feedback-effect takes part with a time constant of one hour or less on the ionization which may have only a short-term role in the initial positive phase (Buonsanto 1988).

Thus percentage deviation values of f_0F_2 ($\Delta f_0F_2(\%)$) are storm time disturbance (Dat) average values of f_0F_2 which have been derived using Med. (monthly Median values of f_0F_2) s with and hourly resolution [$(f_0F_2$-Med.)/ Med.] overlapping SC times that were rounded off to the nearest UT position for each onset of the selected 97 storms with a long lasting period (ι≅2-3d). MSs and ISs which have affected our HF communication channels ever directed attention itself to design a system. The onset of SC was taken as a base point time onset for those both MSs and ISs. A net period of 60h (12h+24h+24h≅2,5d) is beginning from 12h before the SC of storm time and ending in 2d. All samples have been analyzed. Omitting ignorably weak ones and paying special attention in that over 60h, at least for a hole day of 24h, selected storms possessing disturbance value of the field greater than or equal to D (γ) ≥ 24nT or Kp ≥ 4, and smaller than or equal to 120nT (Kp ≅ 7).

The result of overall storm data is given in Figure 1 without any preclassification attempt, over whole 97 individual storm samples. On the horizontal axis superposition

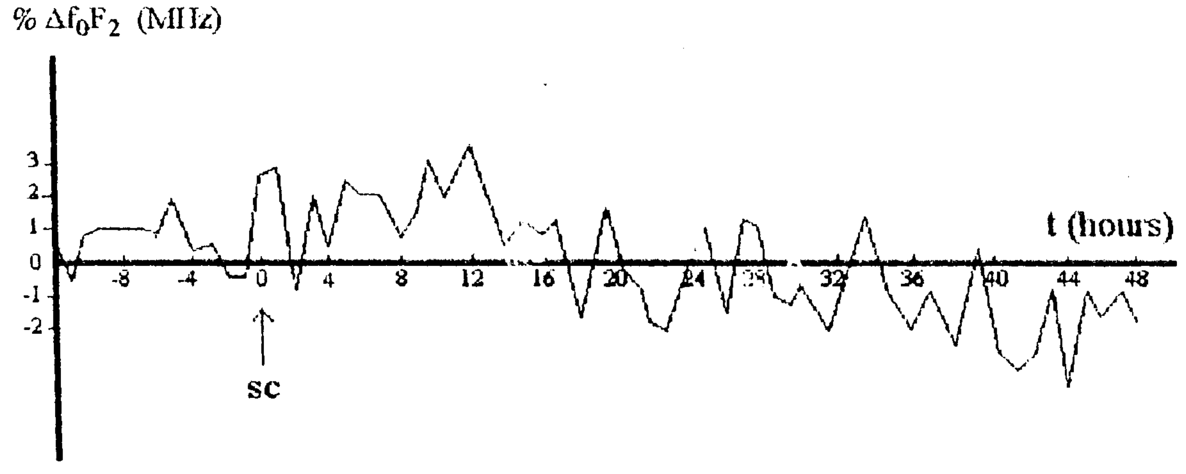

Fig. 1. Percentage deviations of f_0F_2 from monthly medians versus consecutive hours of SSC occurrences for superposed 97 individual storms recorded during the solar activity period of 1964-1970 era in İstanbul.

Şekil 1. 1964-70 Güneş etkinlik döneminde İstanbul'da kaydedilen 97 adet fırtınanın SSC süperpozisyonuyla elde edilen 60 saatlik f_0F_2 değişiminin median değerlerden % Δf_0F_2(MHz) sapmaları.

of the so called net period of storm time hours of 97 storms are signed. On the vertical axis the average hourly values of Δf_0F_2 (%), accompanying ionospheric response aligned to characterize the stormy features of the location. Storms have been studied during the solar activity period of 1964-1970 era through several MSs having notable SSCs (Uyar, 1964). It is strikingly noticeable that factor Δf_0F_2 shows a mutual increase quantitatively accompanying magnetic activity values of Kp ≥ 4 and presents simultaneous changes giving an average extent of about 3-4 % as is measured and computed in our stations (Agopyan and Bulat 1983). This is the first objective result we have achieved in terms of positive storms.

When the responsive short term fluctuations have been filtered with a cut off period of 24h low pass filter from the data we observed the behavior of the overall response more clearly 2d after the SC. The positive phase rapid increase up to 3 % Δf_0F_2 (Figure 2) with its impulsive structure during the first hours of the storm, is followed continuously by a steady long termed increase for a hole day's duration. For the successive days, f_0F_2 readings diminish and flow below the monthly medians $\iota \cong 36h$ later to recover back to their standard values. A resultant fact which must surely be taken into consideration generally as an optimizing term in frequency regulations of HF communications during GSs.

At a predicted f_0F_2 (MHz) = 10 MHz value $\iota \cong 12h$ after the commencement of a storms, the 3-4 (%) extension added it will still be taken as of 10.3-10.4 MHz. Though it seems a very remote approximation, this value may go from 10 MHz up to 17 MHz higher by 70 % increases during a "severe" MS (Agopyan 1988). For further dealings with manipulations when attempted for study purposes to classify the selected storms, any classification will prove centrally different results involved (Matuura 1972). A new approach to the modeling and forecasting of f_0F_2 at quiet and disturbed times using statistical analysis of ionosonde data can be used to define patterns for the main phase effects of mid-latitude ISs (Wrenn and Rodger 1989). It seems the result of a solar flare in those blocout years, which disrupts not only radio soundings, ionospheric radio propagations and LDCs, but also shortwave radio and satellite broadcasts. Radio-receivers fall silent on all short wave (SW) bands during the day time. This interruption may last 1 to 20 minutes. Referring to above example the first SW signals to be heard after a such failure will be those on the HFs over estimated. It is advisable to tune to the higher frequencies. In another word it would be better to lower the meters of the bants available. So if you are listening i.e. on 31 meters, you may want to try to tune 19 meters. It should be kept in mind that sometimes such solar flares are followed hours or days later by ISs that not cause only scintillations on satellite signals but also fading on the higher frequency bands and increased static noise on the lower frequencies. For a positive storm or its positive phase (+p) while bottomside maximum electron density (Nmax) and topside total electron content (N_{TEC}) measurements will always show equivalent concentrations ($+p=\%\Delta Nmax \cong \%\Delta N_{TEC}$), but for a negative IS or its negative phase (-p) there exist double factor between bottomside and topside results ($-p=\%\Delta Nmax \cong 2x\%\Delta N_{TEC}$), that is Nm and TEC concentrations between ΔNmax (%) and $\Delta f_0F_2(\%) \cong [((\%\Delta Nmax/100)+1)^{1/2}-1]x100$ variations, an instant quan-

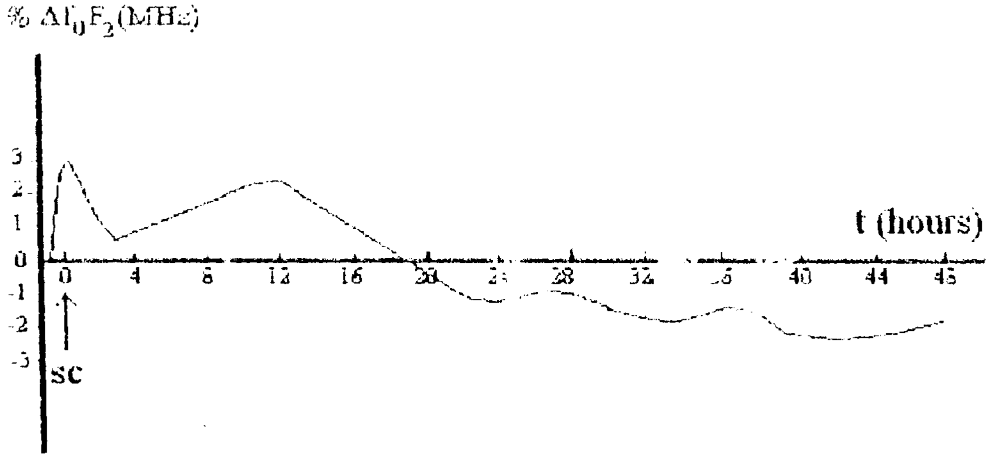

Fig. 2. The positive and negative phases through the 24 hours wavelength of low pass filtration of % f_0F_2 deviations for all storms superposed in Fig. 1.

Şekil 2. Şekil 1 de verilen bütün fırtınalardaki f_0F_2 değişiminin median değerlerden % Δf_0F_2(MHz) sapmalarının 24 saatlik alçak geçişli bir süzgeçle süzülmesiyle elde edilen pozitif ve negatif fazları.

titative value derivation or estimation can be done by the $N \alpha f^2$ relationship. When $\Delta f_0F_2(\%) \cong 70$ (%) then ΔN_{TEC} (%)=15.2(%) (Davies 1982, Mendillo 1986).

The main phase of all ISs ending in $\iota \cong 24$h in fig. 1 shows a considerable increase in intensity over some $\iota \cong 18$h accompanying changes to SSC. The percentage deviation values of F_2 layer critical frequency ($\%\Delta f_0F_2$) experience low values from monthly medians, a condition lasting about $\iota \cong$ 1-2d before recovery back to their normal standards. It was convenient to ignore the storm data values pertaining to prestorm hours $\iota \cong 12$h before of SC, and to observe diurnal effects of storms as well as LT=UT+2h dependence and inclination importance of the station with the SSC occurence and night to day dependences have been presented critically for İstanbul in a previous work (Agopyan 1986).

DISCUSSION

Seasonal classification of the storms have been discussed from the view points of triggerings having daytime or night time onsets. ISs are synchronized with SSCs on the solar activity period of 1964-1970 era through magnetograms and ionograms several MSs and notable SSCs belonging to İstanbul observatories are based on L ≅ 1.6 respectively from İstanbul Kandilli Observatory IKR, 41°03'N 29°04'E and İstanbul Ionosphere Research Station IIAI, 41.°02'N 28.°97'E. The locality of the ground-based instruments were situated on a height level of ≅ 130 meters above the sea level. Classification of 97 storms in the ionosphere have been discussed first in the vicinity of their daytime and nighttime triggerings having possible relative time delay and F_2-layer peak signatures in km and considerable % deviations in MHz by positive or negative phase development present effective features.

İstanbul IS distribution pertains the following number of storm samples (7, 15, 18, 10, 22, 14, 11) per each year following (1964, 1965, 1966, 1967, 1968, 1969, 1970) respectively: 7/1964 15/1965 18/1966 10/1967 22/1968 14/1969 11/1970 Total Nr. of SC STORMS per SEASONDAYTIME and SEASONNIGHTTIME:

Figure 3. a and 3.b: 09S/SUMMERDAYTIME and 06S/SUMMERNIGHTTIME

Figure 4. a and 4.b: 04S/WINTERDAYTIME and 02S/WINTERNIGHTTIME

Figure 5. a and 5.b: 08S/SPRINGDAYTIME and 09S/SPRINGNIGHTTIME

Figure 6. a and 6.b: 010S/AUTUMNDAYTIME and 07S/AUTUMNNIGHTTIME

Before going into detail it would be interesting to note that the era studied pertains the solar cycle 20 (beginning October 1964) have had an equal time lag as the 18th solar cycle (beginning February 1944, while cycle 19 beginning April 1954) and its time lag equality reason still remains unknown. In the 20th solar cycle, 94(%) of the flares could be associated with GSs but we have selected those only non flare associated events from the local measurements. And, on the 20th solar cycle geomagnetic peak activity has been observed during the November of year 1968 and Solar one during the September of 1968.9 during the time of maximum solar activity and during the time of minimum geomagnetic peak on November 1965 and Solar one on July 1964.8 respectively. Considering diurnal variations of the ISs observed minimum and maximum times of UT have been 11.00 UT and 23.00 UT respectively due to the IMF structure on the ionospheric F-region (Gao 1986).

SUMMER STORMS

In Fig. 3a summer months day storms pattern have been presented. There are 9 distinct ionospheric storms accompanying the daytime geomagnetic storms (SC ≅ 13 LT or 11 UT) which are all overlapped and shown in one figure to obtain the general behavior of ionosphere during the summer months of 1964-1970 era which has minima and maxima from the cycle 20 of the solar activity period. The response of the critical frequency f_0F_2 layer of the ionosphere on the vertical axis shows ≅ -5% Δf_0F_2 fluctuations always less than monthly medians for the entire first day period. This feature is valid both before and after the initial and main phases of the GF observed in İstanbul. From the responses of the SC impulse characteristics, it is impossible to detect an average percentage deviation of foF_2 (Mhz) ≥-5% for the events commencing in the LT of the summer. Negative storm pattern (-p) is conspicuos ≅ -10% and there is a reverse +p observed during recovery phase of MS. The maximum electron density fo F_2 layer of the ionosphere undergoes obviously throughout the main phase of the GS. The pattern keeps on about 18h of negative percentage deviations than a gradual increase shows approximately 8h of +p percentage deviations ≅ +10% than decreases off to its former levels. The ionosphere reaches to its normal median values in 48 hours.

In Fig. 3.b summer months night storms pattern have been presented. There are 6 distinct ISs accompanying the nighttime GSs (SC ≅ 00 LT or 22 UT) which are all overlapped and shown in order to obtain the seasonal behavior of ionosphere with the MSs through the summer months of the same years. Storm pattern shows ± 5 to ± 7 % Δf_0F_2 fluctuations having longer rise times than fall times. First impulsive increase appears earlier and than the other increases construct the +p throughout the main phase of the

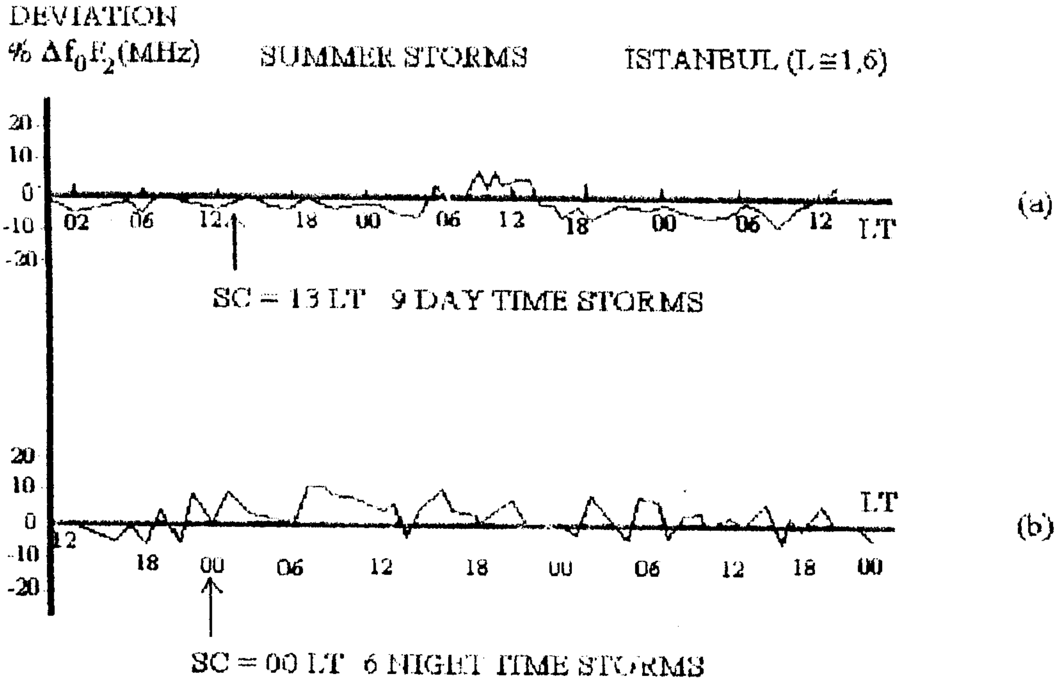

Fig. 3.a.b. Day and nighttime storms of summer months with SSCs recorded during the solar activity period of 1964-1970 era.

Şekil 3.a.b. 1964-70 yıllarının yaz aylarına ait gündüz ve gecevakti fırtınaları.

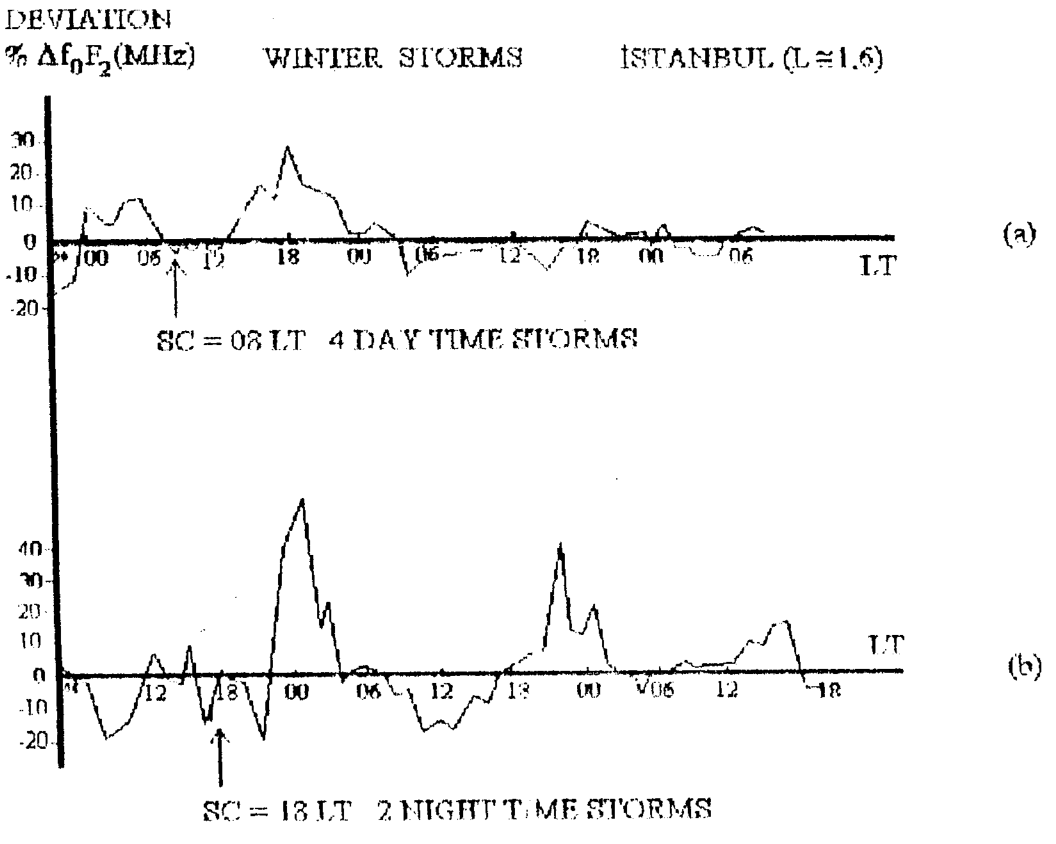

Fig. 4.a.b. Day and nighttime storms of winter months with SSCs recorded during the solar activity period of 1964-1970 era.

Şekil 4.a.b. 1964-70 yıllarının kış aylarına ait gündüz ve gecevakti fırtınaları.

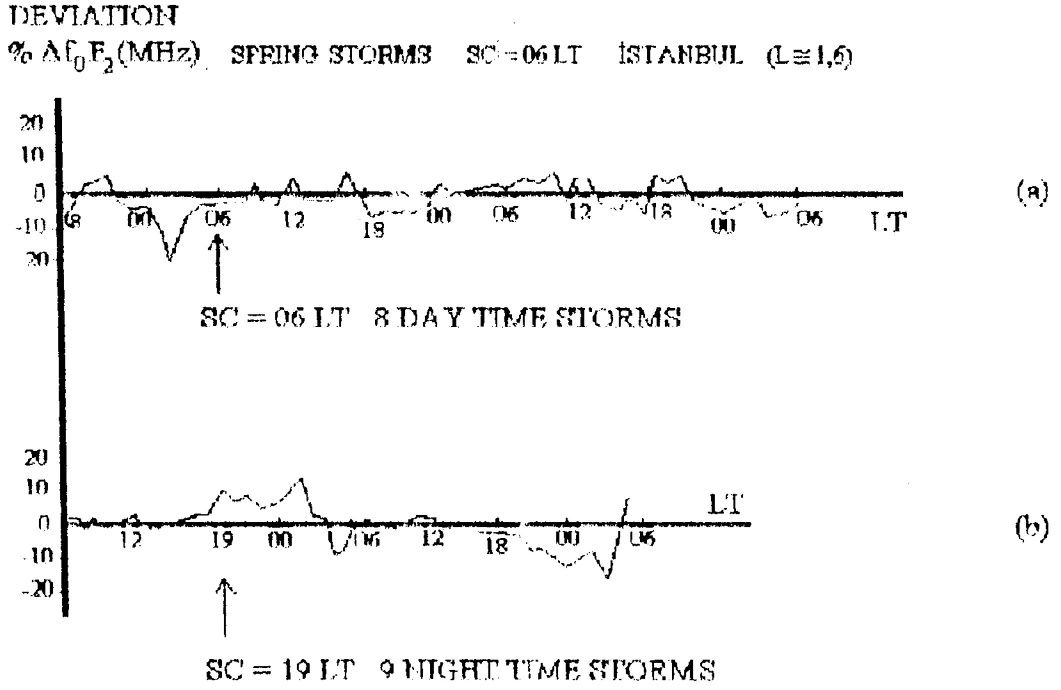

Fig. 5.a.b. Day and nighttime storms of spring months with SSCs recorded during the solar activity period of 1964-1970 era.

Şekil 5.a.b. 1964-70 yıllarının ilkbahar aylarına ait gündüz ve gecevakti fırtınaları.

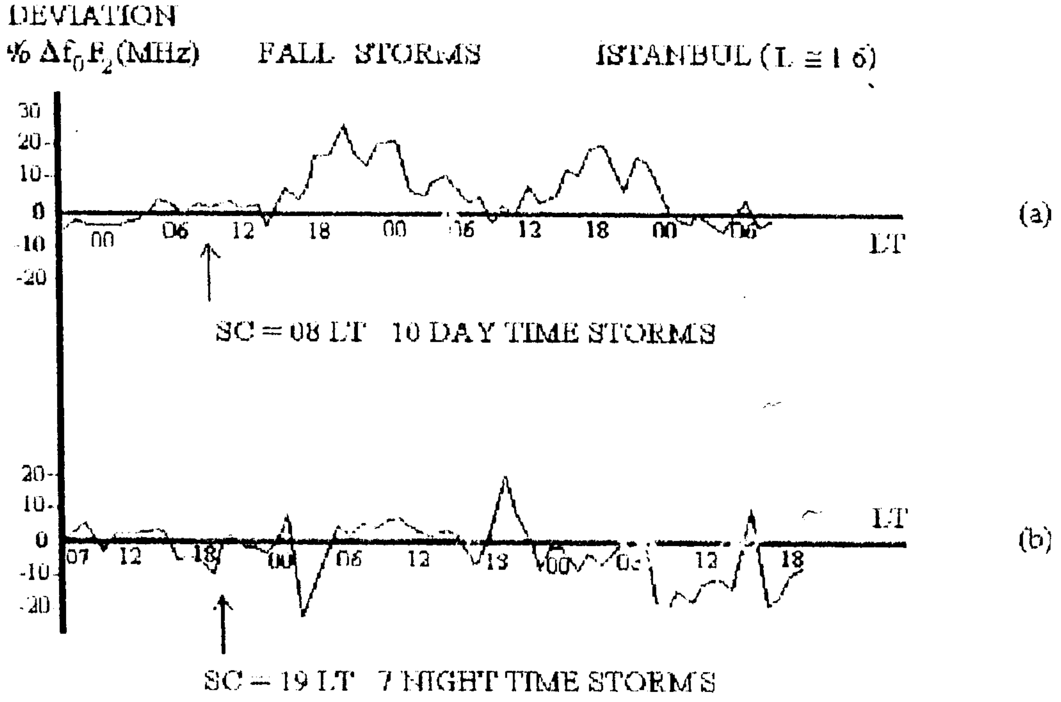

Fig. 6.a.b. Day and nighttime storms of fall months with SSCs recorded during the solar activity period of 1964-1970 era.

Şekil 6.a.b. 1964-70 yıllarının yaz aylarına ait gündüz ve gecevakti fırtınaları.

accompanying SSC and main phases to form the most striking characteristics whence opposite to those of daytime storm features seen in Fig. 3.a. It takes approximately 18h for the main +p of nighttime IS pattern to balance the layer, density, peak and critical frequency deviations back to their former normal levels.

WINTER STORMS

In Fig. 4a winter months day time storms pattern have been presented. There are 4 samples accompanying the daytime GSs which are all overlapped and shown in one pattern to obtain the noontime behavior of the ionosphere during the same era mentioned above. Between the commencement of the GS (SC ≅ 08 LT) and the storm impulse of the ionosphere ≅ + 10 % Δf_0F_2 obviously there exist a phase difference of about 5-6 h in the day time. The maximum electron density of the ionosphere conspicuously increases during the main phase of storm. It is always the evidence detected that before the SC of the GS first +% Δf_0F_2 deviation gains more positive oscillations reaching around ±10 %, elapses within the SC (SC ≅ 08 LT) impact, just a few hours before the beginning of the day showing no deviations from monthly medians. For the entire first day period this feature has been followed by the +p of the daytime IS pattern both before and after the initial and main phases of the MF observed. Notable increases reaching up to ≅ +25% Δf_0F_2 values have been observed in two steps through the main phase of the storm progressing within 3-4 h time delay. Later the response of ionospheric deviations suddenly change their direction from positive to negative throughout all the day until the ionosphere recovers itself relatively. This is the typical evidence of winter day time positive storm characteristics inevitably followed by a -p and the by a positive development. Both phases of storm are damped in 2 days.

In Fig. 4b winter months night storms pattern have been presented. Two distinct types of storm samples could be identified both having the same general characteristics accompanied by the strong MF disturbances (SC ≅ 18 LT) which are overlapped in one figure. The average percentage deviations of f_0F_2 show an oscillation of plasma frequency approximately ± 20% before the storm development. The electron density observed critically has large decreases following (SC ≅ 18 LT) initial and accompanying the main phase onset of the MS. The gradual decrease observed over the f_0F_2 reaching -10% to -20% immediately gains a sharp increase rising continuously by ι≅ 4-5 hours considerably higher than its monthly medians, with -20 to +50 % Δf_0F_2, is a phenomenon remaining in mystery. This should be clarified by means of spectrum analysis of individual storms from the data of the other stations and with the aid of satellite data or other methods.

SPRING STORMS

In Fig. 5a spring months day storms pattern there are 9 distinct ISs accompanying the daytime GSs (SC ≅ 06 LT) which are all overlapped in one figure to obtain the general behavior of ionosphere during the spring months of 1964-1970 era. The response obtained as an average percentage frequency deviations of F_2- layer of the ionosphere, starting in the daytime of the spring months and has an alternating change ranging in the limits of about ± 5 % Δf_0F_2 relatively. There are nearly always ι≅ 5-6h of a delay rate between the SC and the impulsive evidence of the day time ISs observed in the same locality. Considering Nm changes successive to SC ≅ 06 LT we observed that spring day time storms (Fig. 5a) have similar behavioral characteristics as those of summer month day storms accompanied by SC ≅ 13 LT commencements (Fig. 3a) but showing more and shorter phases.

The so-called ionospheric summerlike storm pattern can be derived from similar samples having accompanied by MSs with the same SCs' recorded in different years. As are seen from the figures (Fig. 3 and 5) after many hours regarding to the main phase onset of the MSs, patterns have formed the most striking characteristics of summer and spring daytime storms presenting ± %Δf_0F_2 variations from negative phase to positive.

In Fig. 5b spring months night storms pattern have been presented. There are 9 distinct ISs accompaying the daytime GSs (SC ≅ 19 LT) which are all overlapped in one figure to obtain the general behavior of spring months nighttime storms. There is no obvious retardation between the commencement of the GS (SC ≅ 19 LT) and response to the storm impulse of the ionosphere (± % Δf_0F_2), but the main phase of MF and +p of IS present reverse developments. Positive IS that succeeds the SC impulse with its +p during all the night, with increasing electron density reaching up to its maximum shows 10 to 20 % Δf_0F_2 variations on the pattern. Those are the typical nighttime spring storm characteristics that inevitably will be followed by a -p development on the successive days of all summerlike seasons.

Apart from the difficulty faced to distinguish an IS, whether developing a positive or negative type of storm in lower midlatitudes, northern indice can decrease with a delay of one day or so from the southern, than it is a matter of fact to name the GS as "severe" knowing that developing phase of the IS is local or global, by means of measured data not only from ground based ionosondes but also from on board beacon satellite measurements as well (Klobuchar 1966 and Leitinger et al 1987).

FALL STORMS

In Fig. 6a fall or autumn months day storms pattern have been presented. There are 10 distinct ISs accompanying the daytime GSs (SC ≅ 08 LT) which are all overlapped in one picture to obtain the general behaviors of ISs during fall months. The response of the critical frequency of F_2 layer of the ionosphere on the vertical axis shows ±5% Δf_0F_2 fluctuations but remaining in the vicinity of monthly medians for the whole previous period. Notable increases reaching up to 20 - 30% Δf_0F_2 values have been observed through the main phase of the GS progressing +p of the IS within 5-6 hours time lag. The impulse-like increase being seemingly absent forms the +p event gradually on the first day but without any delay of time on the second day of the +p development. The main phase takes place around 5-6 hours later following the SSC and the ionospheric tidal oscillations follow with a lag of approximately 1.5 - 2 days the SSC. Because of Sc triggerings remain in the forenoon hours general response of IS patterns on the first day seems to have positive behavioral resemblances those observed during the winter months daytime storms (Fig. 4a).

In Fig. 6b autum months night storms pattern have been shown. There are 7 distinct ISs accompanying the daytime GSs (SC ≅ 19 LT) which are plotted all together to form the pattern. It may easily be seen that there is an appreciable phase difference between the SSC onset and the impulsive deviation of f_0F_2 (± 10 % Δf_0F_2). So it may need more research work for its further clarification. Without detailed analysis of individual ISs, it will be quite difficult to identify their negative variations and the reason of recurrent impulsive peaks, depending on a daily period (≅ 24 hours) with the relative rotation of the ionosphere-observatory decreasingly changing ± 10% - ± 20% Δf_0F_2 on the first day with a delay of 6-7 hours of SC which is not clear yet to predict their sharp -p and to express their delay time.

For the being, it would be tacitly the most convenient approach to accept present "L" understanding enough to the importance of storm studies given in section "Geomagnetic Modification" of the "Introduction".

CONCLUSIONS

There were no enough useful data for some special storms due to lack of IS measurements during disturbed days.

First, considering the southern hemisphere densities that were lower than those of in the lower hemisphere (Tulunay and Grebowsky 1987) depending on the solar control NmF_2 can be abnormally high because of the semi annual anomaly not only at equinoxes but also in the beginning of the winters too.

Secondly, because the temperature equality of electrons and ions (Te ≅ Ti) plays a very important role on the massive displacement of the ionospheric constituents, along the geomagnetic field lines during winter night times ionization uplifting dominates to daily transport phenomena at night time ambipolar diffusion reverse in relative accordance with the eastward rotation velocity (500m/s) of the observatory. But during day times ionospheric stratification like D, E, F_1 and F_2 helps to charge exchanges with the increased Te ≥ Ti. Temperature of electron mobility, and by more absorption, increases its horizontal conductivity to establish lower dipolar L-shells, which tends to move to the higher distances during the night times of stormy conditions because of increased night time vacuum effect produced by the solar wind parameters on the antisunward sites where having L ≅ 1-2 value or similar of sub ionospheric points. In the ionosphere, mainly its thermospheric height moves both horizontal and vertical then becomes an active filter rather than showing passive filter characteristics.

In order to overcome faced ionospheric prediction and forecasting limitations using experimental parameters and computational methods, IS an GS measurements and analysis should be done more, and more for various solar cycle conditions and with different storms. For further research, not only solar sunspot numbers, but also effect of the inner and outer energy sources should be taken into consideration apart from the magnetosphere ionosphere coupling and reconnection according to sunward solar wind pressure and antisunward vacuum effect.

After the seasonal classification of the GS and ISs; Summer and Spring storms as summerlike, Winter and Fall storms as winterlike events, according to the SSC onset time and phase lags between ISs and H-component variation of MF [ΔH (t)] and the most important geomagnetic activity dependent deviations (SSC, B, H, Z, D, Kp and LT). Thus the time delay comparitions between overlapped day and night time storms verifies the validity of current understanding. The results (% Δf_0F_2, NmF_2) as LT dependent deviations of summerlike [ΔNmS (t)] and winterlike [ΔNmW (t)] events generally have been summarized in two groups:

(1) Daytime events: [ΔDt= ΔH±ΔNm (t≅ 3h-6h)] with 3-6h time delay. At any onset happening in daytime, IS always follows the MS commoncement with a delay as a matter of hours. While NmF_2 values still have seasonal variations, characteristic, but with an earlier -p in sumerlike events and a late positive in winterlike events presumably due to production rate To > Ti > Tn and relatively low decreases in electron density ($O^+ + H \Longrightarrow O + H^+$) because of daytime-summer ionic temperature (Ti) is greater than daytime-winter-Ti (Buonsanto 1988).

(2) Nighttime events: [$\Delta Dt = \Delta H \pm \Delta Nm$ ($\iota \leq 1h$)] no noticeable time lag. At nighttime (To ≅ Ti), the IS shows no delay from SC in hourly time scale while behavioral changes happen to be in opposite directions ($O + H^+ \Longrightarrow O^+ + H$) with a +p for summerlike and negative one for winterlike events. In summer, noontime solar Rmax Te > Te Rmin (Buonsanto 1988). During disturbed conditions an increse in Te has the following reasons accepteble due to

i. - soft particle precipitation from ring currents.

ii. - heating associated by stable auroral red (SAR) arcs, or

iii. - decreased cooling due to lower electron density (Ne) in the ionisation through which moves equatorward during storms.

During nighttime due to the convergence of the layer along GF lines it is reasonnable not to observe any delay in summerlike events, and also due to the winter anomaly, during daytime hours winterlike events will show more and longer delay times ($\iota \cong$ 5-6h) than summerlike events having shorter time lags (≤3-4h) with their reverse phases by the domination of transport and drift phenomena. On the real height electron concentration profiles, the observed minimum ionospheric F_2 layer heights undergoing around below 250 Km level because the F_2 layer of the ionosphere over İstanbul presents winterlike seasonal characteristic, which shows higher base level for the F_2 region being diminished with its electron concentration and layer peak around $hpF_2 \cong 300$ Km.

In winter, the MS causes NmF_2 increase in density, and because hmF_2 layers form at comparatively lower altitudes, (Bulat and Agopyan 1980 and Capannini et al 1982), the ratio of N_2/O presents comparatively significant changes which have in Fig. 4., as claimed (Proelss 1980, Powerlein and Neske 1980), referring to the data collected through their experimental studies some likeliness to the observed increase in Ne in F-region. This is due to plasma transport to higher altitudes. An increase of N_2/O ratio (or decrease of O/N_2 that is known as sink or collapse in NmF_2 or downwelling, upward motion of air, occurs remote from energy inputs) decreases the Ne. Ionospheric electron production $Q = AR/e^{kT/mg}$ A= Absorbed energy, R= Radiation flux, k= Boltzman constant (k= P/nT; P: pressure, n: number density, T: Temperature °K), m= molecular weight and g= gravitation which is directly proportional to atomic O density and inversely to the "scale height" Hs= kT/mg and the ionospheric loss (β) is based on both to molecular Nitrogen and to the Ne, that is the more Hs gains, Q will lose or vice versa. So during high solar activity, ionospheric temperature will increase while Q and accordingly NmF_2 quantities may produce lesser numerical readings. The fact that the energy (keV) necessary to cause ionization of N_2 is considerably less, in amount, than that for the ionic Oxygen production, O^+, which renders the increases in NmF_2 due to particle precipitations based on LT ($NmF_2 \cong q/\beta \cong I\, [O]/[N_2]$. As a matter of this fact connected to high solar activity Zurich sunspot numbers ($\bar{R}$) throughout the years 1963-1970 correlation between vertical cross section density has subpeak electron content ($\bar{I}$) found as $I = 2{,}83\,(1+0{,}073\,\bar{R})\,10^{19}\,\mathrm{el.cm^{-2}}$ (Bulat and Agopyan 1980).

During the initial phase when the energy is deposited to auroral regions meridianal winds start to blow toward the equator and drive the ionospheric plasma along the geomagnetic field lines into greater heights where the lower density of N_2 diminishes the loss rate. Therefore during the first few hours NmF_2 increases and the height of NmF_2 shifts to greater altitudes. After several hours a "severe" storm, with the global wind cells have fully developed, and wind induced diffusion reduces the ratio O/N_2, thus resulting in a decrease of NmF_2 at higher latitudes, causing the main negative phase of the ionospheric storm. A negative phase can be observed at high and middle latitudes and a positive phase at low latitudes because of atomic oxygen transportation toward the equator and the wind induced diffusion contribute jointly to increase electron density. Important in this respect is the phase delay between the wind maximum and of the ratio N_2/O which may be of the order of one day during major storms (Volland 1983). The delay of one day is probably due to the injection of ring current particles being more rapid than the removal of plasmaspheric convection field (Song et al 1988). Ionospheric extreme temperature and composition changes are the parameters required for weakly ionized plasmatic fluid at the exobase for evaluating fundamentally the upward flux of electrons which governs the refilling process of the plasmasphere.

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