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CHILTON İSTASYONU ÜZERİNDEN ÖLÇÜLEN VE IRI-2001 MODELİYLE ELDE EDİLEN MAKSİMUM ELEKTRON YOĞUNLUĞUNUN KARŞILAŞTIRILMASI

ÖZET

Bu çalışmada, NmF2 verileri (51,70 °K; 358, 67 °D) coğrafik koordinatlarda Chilton istasyonunda medyan olarak ölçüldü. Bunun yanısıra NmF2 değerleri aynı coğrafik koordinatlar için IRI-2001 modeli kullanılarak elde edildi. Ölçülen ve hesaplanan değerler mevsimsel ve yıllık olarak karşılaştırıldı. Ölçülen ve hesaplanan maksimum elektron yoğunluğu değişimleri mevsimsel ve yıllık olarak araştırılmıştır. Iyonosferin F2-bölgesinde ölçülen ve hesaplanan maksimum elektron yoğunluğu arasında tam bir uyum vardır. Bu uyum, korelasyon katsayısı ile verilmiştir.

Anahtar Kelimeler: Maksimum Elektron Yoğunluğu, İyonosferin F2-Bölgesi, IRI–2001 Model, Ionsonda, Plazma Frekansı

COMPARISON OF MAXIMUM ELECTRON DENSITY PREDICTED BY IRI-2001 WITH THAT MEASURED OVER CHILTON STATION

ABSTRACT

In this study, N_mF2 data were measured as median at geographic coordinates (51,70 °K; 358, 67 °D) for Chilton station. In addition, N_mF2 values were calculated by using IRI(International Reference Ionosphere)-2001 model for same coordinates. The values of measured and calculated were compared as seasonal and annual. The changes of measured and calculated maximum electron density have also been investigated as seasonal and annual. There is an exact harmony between the results of calculated the maximum electron density with IRI-2001 model and measured at F2-region in ionospheric plasma. The harmony has been given by correlation coefficients.

Keywords: The Maximum Electron Density, F2-Region of Ionosphere, IRI-2001 Model, Ionosonde, Plasma Frequency

1. INTRODUCTION (GIRIŞ)

Ionosphere physics may be regarded as a branch of aeronomy, the science of the atmosphere. Ionosphere physics is related to also plasma physics because the ionosphere is, of course, a weak natural plasma: an electrically neutral assembly of ions and electrons [1, 2, 3 and 4]. The ionosphere plays a unique role in the Earth's environment because of strong coupling process to regions below and above [5 and 6]. The ionosphere is an example of naturally occurring plasma formed by solar photo-ionization and soft x-ray radiation. Ultraviolet radiation from the sun ionizes the atmospheric constituents. Free thermal (1 < eV) electrons and ions are present in the earth's upper atmosphere between 50 km and 6000 km approximately. In this region, the atmospheric temperature first increases with altitude to an overall maximum value (~900^0K) and then becomes constant with altitude In the ionosphere, a balance between photo-ionization and various loss mechanisms gives rise to an equilibrium density of free electrons and ions with a horizontal stratified structure. The density of these electrons is a function of the height above the earth's surface and is dramatically affected by the effects of sunrise and sunset, especially at the lower altitudes. The presence of these free electrons in the ionosphere can influence the propagation of radio waves. The ionosphere is conventionally divided into the D-, E-, and F-regions [2 and 3] The D-region lies between 60 and 95 km, the E-region between 95 and 150 km, and the F-region lies above 150 km. In daylight, it is possible to distinguish two separate layers within the F-region, the F1 (lower) and the F2 (upper) layers [2]. During nighttime, these two layers combine into one single layer. The combined effect of gravitationally decreasing densities of neutral atoms and molecules and increasing intensity of ionizing solar ultra-violet radiation with increasing altitudes, gives a maximum plasma density during daytime in the F-region at a few hundred kilometers altitude. During daytime, the ratio of charged particles to neutral particles concentration can vary from10^{-8} at 100 km to 10^{-4} at 300 km and 10^{-1} at 1000 km altitude. The main property of F-region consists of the free electrons and is a very important region for radio communication. Within the F-region the main features of the vertical distribution of electrons are the F1 "ledge" at about 160 to 200 km, present only at times and F2 "peak" which generally lies between 200 and 400 km. The F2 layer is the most important ionospheric layer from the point of view of the radio communication [7, 8 and 10]. The oldest of these stations is Slough, England, which began regular operation in 1931. This is because it contains the greatest concentration of free electrons, and can therefore reflect radio waves of a higher frequency than can the other layers. In principle a through understanding of F region physics could lead to better utilization of the ionosphere for communication purposes. The available information pertaining to F region falls in various categories. The most important parameter is the electron density, or electron concentration N, which is a function of altitude and local time, and may vary considerably with location and season. The basic data on electron density are obtained by pulse soundings at vertical incidence [12]. The electron density in ionosphere depends on some process which called the dynamics (into ionosphere) and photo-chemical processes (out of ionosphere).

2. RESEARCH SIGNIFICATION (ARAŞTIRMANIN ÖNEMİ)

The present study intends to serve as guide for researcher who make theoretical studies about the critical frequency ionosphere F2-Region. It is to also test IRI-2001 model with the experimental data.

3. THE CALCULATION OF ELECTRON DENSITY WITH IRI-2001 MODEL AT F2 REGION (F2 BÖLGESINDE IRI-2001 MODELIYLE ELEKTRON YOĞUNLUĞUNUN HESAPLANMASI)

Propagation of electromagnetic waves in the atmosphere is influenced by the spatial disturbution of the refractive index of the ionosphere [1]. The presence of the earth's magnetic field makes the ionosphere a double refractive medium. When an electromagnetic (EM) wave of frequency f_0 from the ground enters the ionospheric D-region its refraction depends on the initial polarization state of the incident wave. Two types of waves are most commonly used in the ionospheric modification experiments, namely ordinary (O-mode) and extraordinary (X-mode) waves. From the ordinary critical frequncies f_0 of the various layers, the corresponding peak electron densities are deduced by a well-known standart Formula [2 and 3]

$$N_m F2 = \frac{f_0^2}{80.6} \qquad (1)$$

and similiraly fort the order layers, the frequencies f_0 being in Hz and N_m in electrons per cubic meter. Where N_m: the electron density at F2 peak and f_0: the wave frequency.

4. NUMERICAL SOLUTIONS AND DISCUSSION (NUMERIK SONUÇLAR VE TARTIŞMA)

In this study, N_mF2 data were measured as median at geographic coordinates (51,70°K; 358, 67°D) for Chilton station. In addition, N_mF2 values were calculated by using IRI-2001 model for same coordinates. The values of measured and calculated were compared as seasonal and annual. The changes of measured and calculated maximum electron density have also been investigated as seasonal and annual. The f0F2 data measured at Chilton station has been chancing between 1994-2006 years. For the same years, the maximum electron density at the F2 peak as numerical has been obtained by using IRI-2001 model. The maximum electron density both measured and calculated has been investigated as annual and seasonal, with respect to local time. Whether a relationship between the maximum electron densities of measured and calculated exit, among of them depend on the correlation coefficients. The correlation coefficients have been given by Table 1.

There is an exact harmony between the results of calculated maximum electron density with IRI-2001 model and measured at F2-region in ionospheric plasma. The harmony has been given by correlation coefficients.

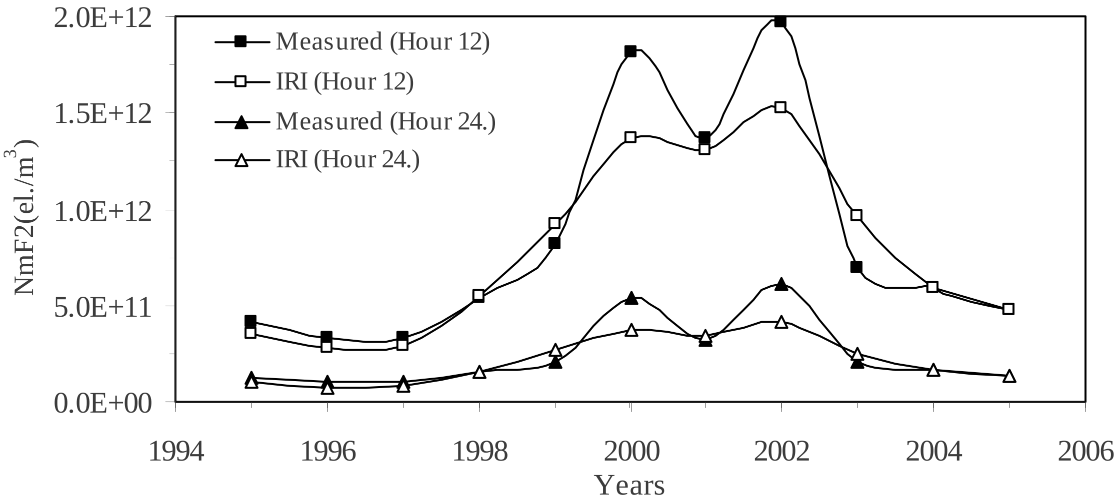

Figure 1. The diagram with respect to years of the maximum electron density of the measured and calculated for March
(Şekil 1. Mart ayı için ölçülen ve hesaplanan maksimum elektron yıllara göre değişimi)

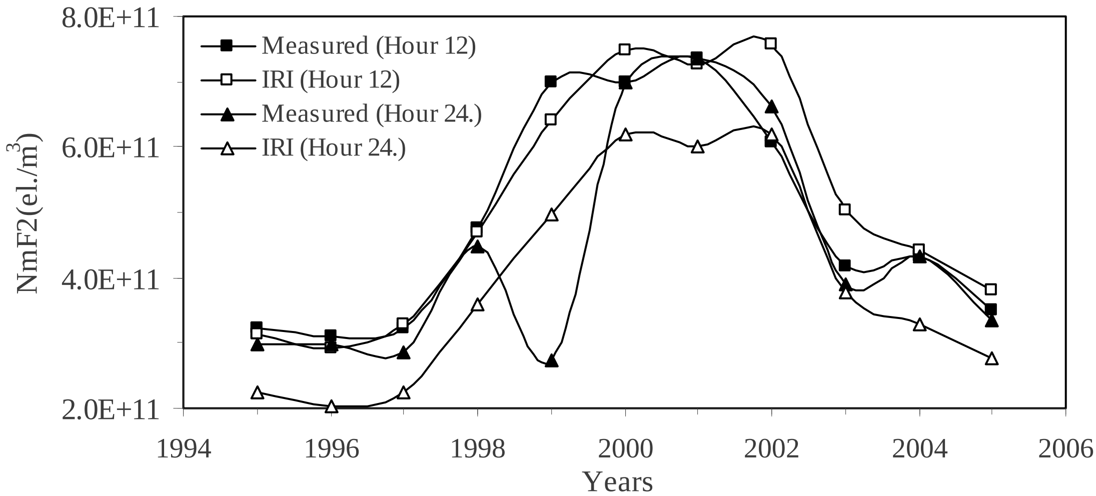

Figure 2. The diagram with respect to years of the maximum electron density of the measured and calculated For june
(Şekil 2. Haziran ayı için ölçülen ve hesaplanan maksimum elektron yoğunluğunun yıllara göre değişimi)

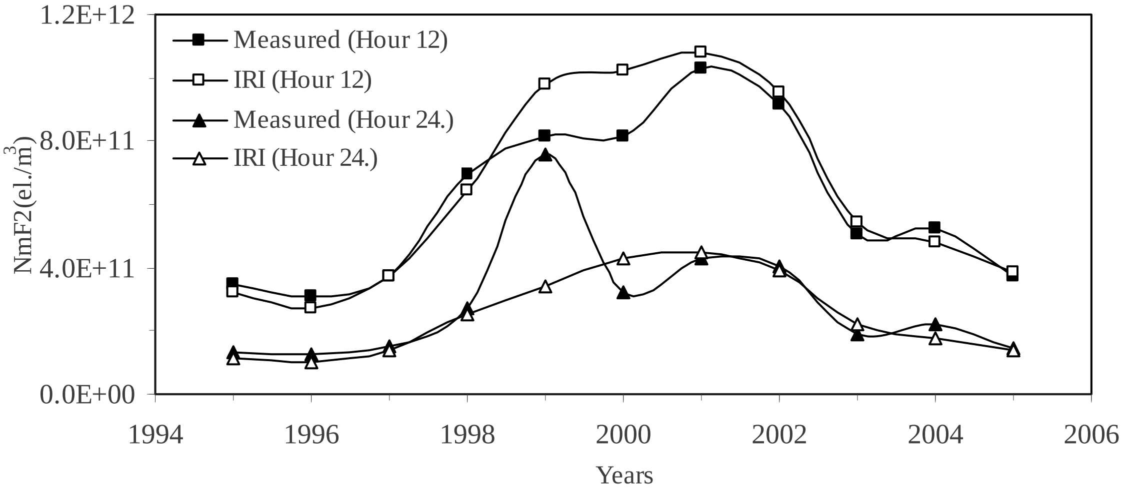

Figure 3. The diagram with respect to years of the maximum electron density of the measured and calculated for september
(Şekil 3. Eylül ayı ölçülen ve hesaplanan maksimum elektron yoğunluğunun yıllara göre değişimi)

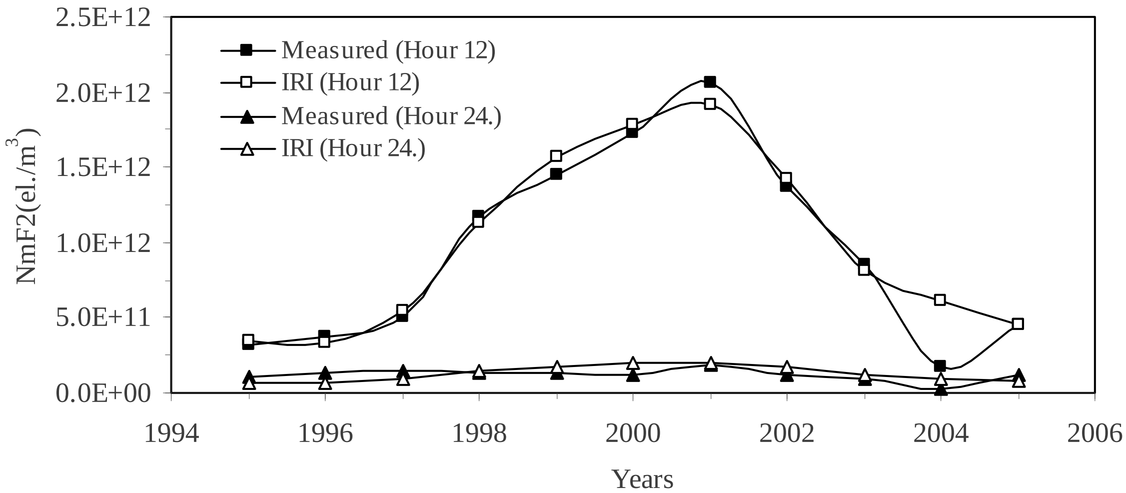

Figure 4. The diagram with respect to years of the maximum electron density of the measured and calculated for december
(Şekil 4. Aralık ayı için ölçülen ve hesaplanan maksimum elektron yoğunluğunun yıllara göre değişimi)

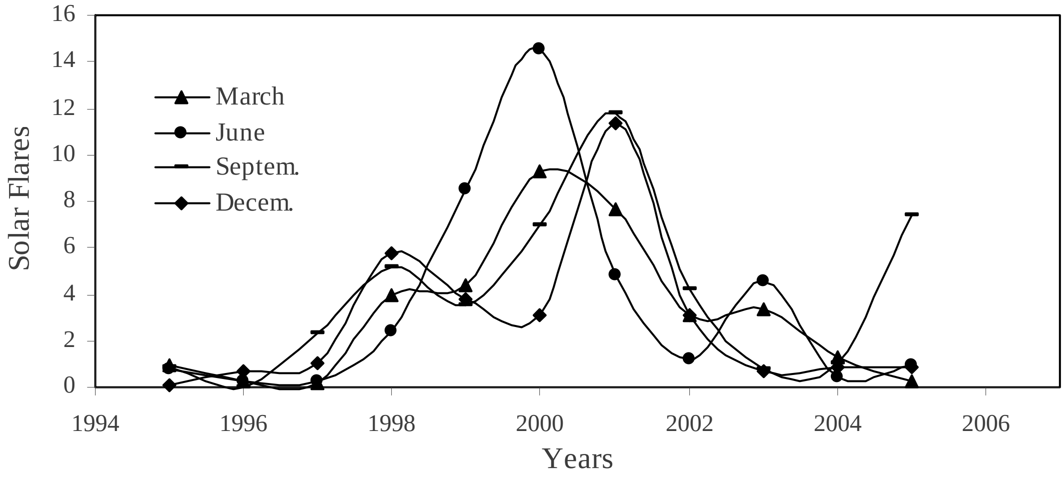

Figure 5. The sunspot number profile between 1995-2005 years [9]
(Şekil 5. Güneş patlamalarının 1995-2005 yılları arasındaki değişimi [9])

Table 1. The change with respect to years of correlation coefficients of the measured and calculated as seasonal and annual
(Tablo 1. Ölçülen ve Hesaplanan maksimum elektron yoğunluğu değerleri için korelasyon katsayının yıllara göre mevsimsel olarak değişimi)

Years	$r_{x;y}$ (March)	$r_{x;y}$ (June)	$r_{x;y}$ (September)	$r_{x;y}$ (December)
2005	0.905966	0.874311	0.892003	0.935627
2004	0.732062	0.502985	0.790239	0.92806
2003	0.800549	0.899096	0.762335	0.950747
2002	0.865241	0.568222	0.855549	0.950188
2001	0.8492	0.88217	0.82675	0.937553
2000	0.916668	0.729576	0.89381	0.952331
1999	0.888606	0.868518	0.823899	0.947221
1998	0.924381	0.825365	0.910118	0.961924
1997	0.949852	0.820814	0.920321	0.927882
1996	0.937745	0.859546	0.883883	0.917215
1995	0.889577	0.854342	0.865651	0.895963

List of Symbols
NmF2 : The maximum electron density of F2-Region
f0 : The critical frequency of F-Region

REFERENCES (KAYNAKLAR)

1. Hunsucker, R.D. and Hargreaves, J.K., (2003). The High-Latitude Ionosphere and its Effects on Radio Propagation, Cambridge University Press, 1-50
2. Rishbeth, H., (1973). Physics and Chemistry of the Ionospheric Contemp, Phys, 14,229, 240
3. Rishbeth, H. and Garriot, O.K., (1969). *Introduction to Ionospheric Physics*, Academic Pres, New York
4. Abur-Robb, M.F.K., (1969). Combined World-Wide Neutral Air Wind And Electrodynamic Drift Effects On The F2-Layer, Planet Space Sci., 17, 1269-1279.
5. Bailey, G.J., Su, Y.Z., and Oyama, K.I., (2000). Yearly Variations In The Low-Latitude Topside Ionosphere, Ann. Geophysicae, 18, 789-798
6. Rishbeth, H., (1967). A Review of Ionospheric F Region Theory, Proceedings of The Iee, 55, 16-35.

7. Zhang, S.R., Oliver, W.L., Fukao, S., and Otsuka, Y., (2000). A Study of The Forenoon Ionospheric F2-Layer Behavior Over The Middle and Upper Atmospheric Radar, Journal of Geophysical Research, 105, 15, 823-15, 833.
8. Millward, G.H., Rishbeth, H., Fuller-Rowell, T.J., Aylward, A.D., Quegan, S., and Moffett, R.J., (1996). Ionospheric F2-Layer Seasonal and Semiannual Variations, Journal of Geophysical Research, 101, 5149-5156.
9. http://www.haarp.alaska.edu
10. Rapoport, Z. Ts. and Sinel'nikov, V.M., (1998). Experimental Electron Concentration Profiles Of The Midlatitude Lower Ionosphere and The Winter Anomaly, International Journal of Geomagnetism and Aeronomy, 1, 2-7
11. http:/www.ngdc.noaa.gov./
12. Chien-Chih Lee, Bodo W. Reinisch, Quiet-Condition hmF2, NmF2, and B_0 variations at Jicamarca and comparison with IRI-2001 during solar maximum, Journal of Atmospheric and Solar-Terrestial Physics, 68, 2138-2146.