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Research Article

Comparison of Wavelet Characterization of Computed Perturbed and Un-perturbed Parcel Velocities of F_2 Layer

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Abstract: In recent years, the understanding of various phenomena pertaining to space science and consequently the predictability of naturally occurring phenomena have improved. Wavelet is a tool for displaying and analyzing data and wavelet basis are considered a useful tool for understanding local behavior. Ionosphere F_2 layer is situated at about 250–425 km from above the earth surface; this is a region of magnetosphere. Therefore, there exist some ionospheric effects due to solar activity and diurnal variation. In this study, we analyzed computed perturbed and un-perturbed parcel velocities of ionospheric F_2 layer using spectral and wavelet analysis. The level 5 of Haar wavelet has been reported in the forms of approximation model, detailed statistics and reconstructed model by decomposition. In this communication we have presented the comparison of wavelet characterization for computed perturbed and un-perturbed parcel velocities of ionospheric F_2 layer at the Pakistan air space.

Keywords: Ionosphere, magnetosphere, spectral, wavelet, haar, parcel velocity, F_2 layer, decomposition

1. INTRODUCTION

The information gained in some space projects has added to our understanding of the earth as well as to our knowledge of space. For example, weather satellites have enhanced our comprehension about the change of weather conditions in a world-wide scale. The earth and space are studied together because these have strong correlation to each other. The part of atmosphere above 80 km from the earth surface, where free electrons exist in numbers sufficient to influence the radio wave propagation is called ionosphere. The ionospheric that is situated from 80–1000 km consists of different layers such as D, E and F (F_1 and F_2) layers. We present comparison of wavelet characterization of computed perturbed and un-perturbed parcel velocities of ionospheric F_2 layer at Pakistan air space. It is a familiar fact that considerable increase in the flux of UV radiation during solar flares sharply increases the ionization on the illuminated side of the earth and leads to a radical deterioration or even complete termination of radio communication on short wavelengths. During this period, ionospheric perturbation has also been observed by some investigators. We analyzed computed perturbed and un-perturbed parcel velocities of ionospheric F_2 layer by using spectral and Haar wavelet analyses [1-4].

2. MATERIAL AND METHODS

In this communication it has been investigated that the ionospheric disturbances may travel through the ionosphere and give rise to fluctuations in the signals that can only be determined by statistical model as mentioned in the CCIR Report 263–5, 1982. Wavelet transforms as MATLAB utility has been implemented.

2.1 Parcel velocity Ionospheric Layers

Because the earth is a rotating sphere, points on the Earth's surface move at different speed depending on their latitude. Consider a point completing a

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circle of radius R in time t. Its tangential speed is:

$v = 2\pi R / t$

The angular velocity (Ω) in radians per second, is $2\pi / t$ since 2π radians is the angle covered in t seconds thus $v = \Omega R$ the angular velocity of the Earth is $2\pi/(24*60*60) = 7.27*10^{-5}\, radians / second$

since the Earth's radius at the equator is about 6370 kilometers, the tangential speed of a point on the surface at the equator is v = 463 m / s at the latitude Φ, the radius of the circle described by a point on the surface is $RCos\Phi$, so that the tangential speed is $v = \Omega RCos\Phi$ which is just $Cos\Phi$ times the speed at the equator at latitude 30^o, a parcel of upper-level air transported from the equator has "surplus " momentum corresponding to a velocity at height of the space h

$$V_{PARCEL} = \Omega(R + h)Cos\Phi$$

2.2 Perturbation Parcel Velocity

Parcel of upper-level air transported from the equator has "surplus" momentum corresponding to a velocity at height of the space h. By Reynolds Decomposition Method Reynolds assumption

$V = \bar{V} + V^{/}$,

the average and perturbation velocity for Ionospheric layers. Advection is the mean horizontal velocity [5].

3. RESULTS AND DISCUSSION

3.1 Spectral Analysis

Spectral analysis is a signal processing method aimed at, instead of the active patterns of signals in the frequency domain. We computed perturbed and unperturbed parcel velocities clearly appear to follow a cyclical pattern as shown in Fig. 1(i), (ii), (iii), (iv), the line spectrum on periodogram Fig. 2(i), (ii), (iii), (iv) and Table 1, 2 and 3 constructed to identify the randomness in the ionospheric, computed perturbed and unperturbed parcel velocities due to influences of solar activity and other factors. The purpose of spectral analysis is to examine data series in term of their frequency content. Frequency domain analysis has become much more central to our aptitude to decode the cause and effect of upper atmospheric changes. Review of the result shows that the five largest peak frequencies are five largest periodogram peaks for computed perturbed and unperturbed parcel velocities. The large peaks are identified in the periodogram. The number of observations 365, number of observations after padding: 364 and Transformations: Computed Means perturbed and unperturbed parcel velocities are 3.275 and 207.38 subtracted [6-9]. Largest Peak Frequencies, obtained for Perturbed and Un-Perturbed Parcel Velocities and other peaks, are given in the Table 1.

Table 1 Value: Frequency**.**

(1)	49.66: 0.003
(2)	7.759: 0.033
(3)	3.470: 0.038
(4)	2.121: 0.005
(5)	1.305: 0.035
	&
(1)	181.2: 0.003
(2)	28.84: 0.033
(3)	12.22: 0.038
(4)	6.676: 0.005
(5)	6.393: 0.008

Table 2 Spectral component values for ionospheric perturbed parcel velocity, frequency (F), period (P), coefficient Cos and coefficient of Sine & periodogram (Pgm).

F:	P:	Cos:	Sin:	Pgm:
0.000		0.002	0.000	0.002
0.002	364	-0.522	-0.001	49.65
0.005	182	0.105	0.022	2.120
0.008	121	-0.050	0.045	0.830
0.010	091	-0.071	0.099	2.734

Table 3 Spectral component values for ionospheric Un-perturbed parcel velocity, frequency (F), period (P), coefficient Cos and coefficient of Sine & periodo-gram (Pgm).

F:	P:	Cos:	S in:	Pgm:
0.000		0.005	0.000	0.005
0.002	364	-0.992	-0.042	181.1
0.005	182	0.183	0.055	6.665
0.008	121	-0.120	0.1.43	6.39
0.010	091	-0.019	-0.123	2.847

3.2 Wavelet Analysis

Wavelet analysis is a powerful tool to find the mode of variations and also to study how it varies with time by decomposing time series into frequency space. This decomposes actual signal into different signals to be analyzed into principal and residual part. In this work Haar wavelet is used of level 5, the dyadic scale is $a = 2^j$ for level 5 the resolution is given by 1/a, or 2^{-j}. In order to approach the cyclic study maximum and minimum values, we have carried out analysis of ionospheric F_2 layer perturbed and un-perturbed parcel velocities, as shown in Fig. 3, 4. The variation is presented for different resolution at level 5 of Harr in the detailed and approximated part of the cyclic variation. It has also been manifested that at different levels of detailed and approximated parts the lowest resolutions peaks appeared. Fig. 5 and 6 illustrate residual analysis for un-perturbed and perturbed parcel velocities of ionosphere at Pakistan air space. The decomposition at level 1, 2, 3, 4, and 5 is shown, respectively [10-12] as:

$$s = a_1 + d_1,\quad s = a_2 + d_2 + d_1,$$

$$s = a_3 + d_3 + d_2 + d_1,$$

$$s = a_4 + d_4 + d_3 + d_2 + d_1,$$

$$s = a_5 + d_5 + d_4 + d_3 + d_2 + d_1$$

The advance and more recent analysis of ionospheric F_2 layer perturbed and un-perturbed parcel velocities between 1 to 365 components data point. We have constructed model ionospheric data. We used wavelet transformation that has become a

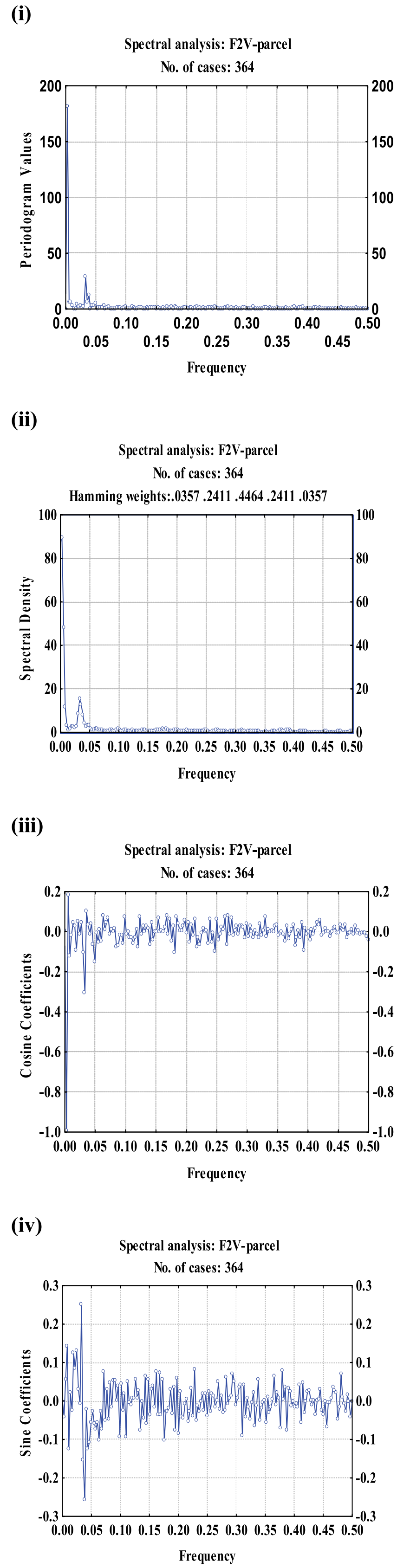

Fig. 1 Spectral analysis for un-perturbed parcel velocity of ionospheric region of Pakistan.

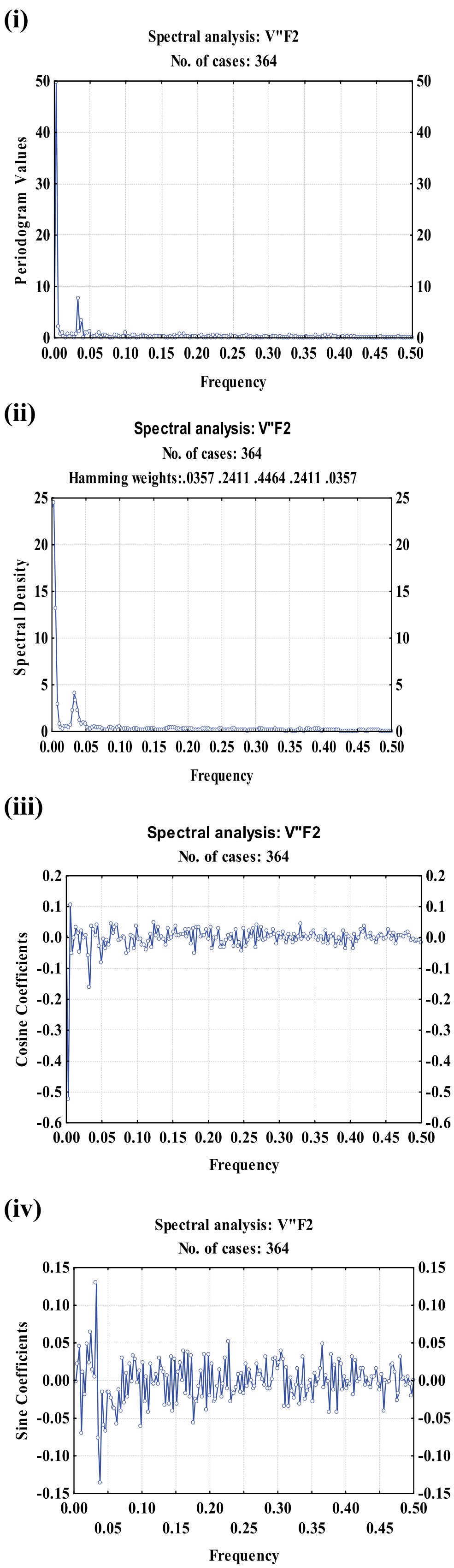

Fig. 2 Spectral analysis for perturbed parcel velocity of ionospheric region of Pakistan.

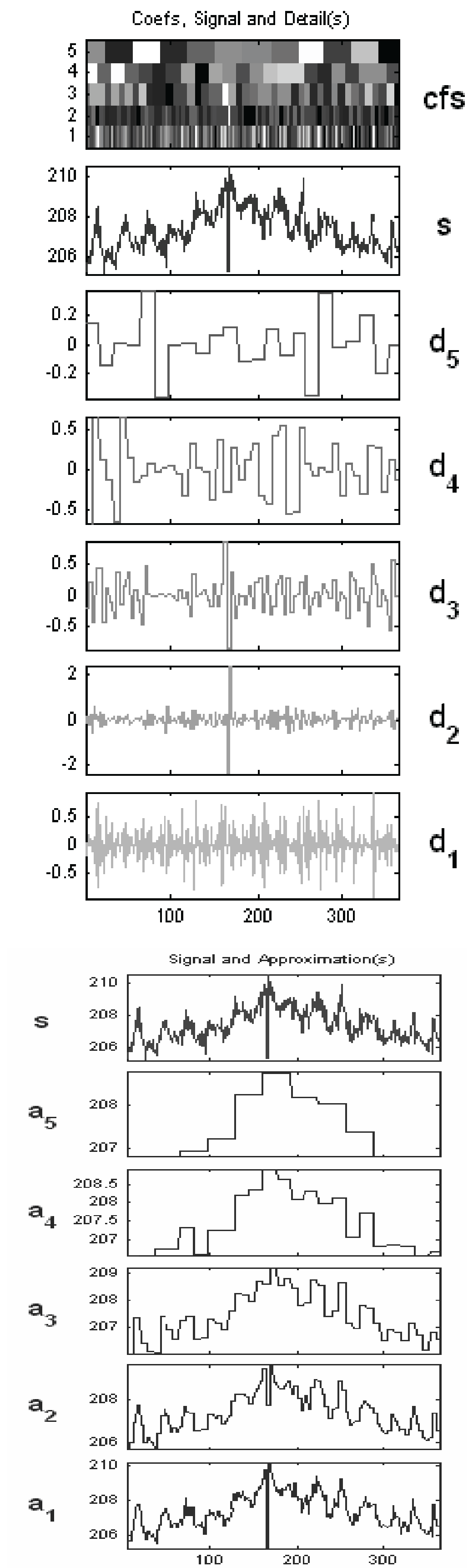

Fig. 3 Wavelet analysis for un-perturbed parcel velocity of ionosphere at Pakistan air space.

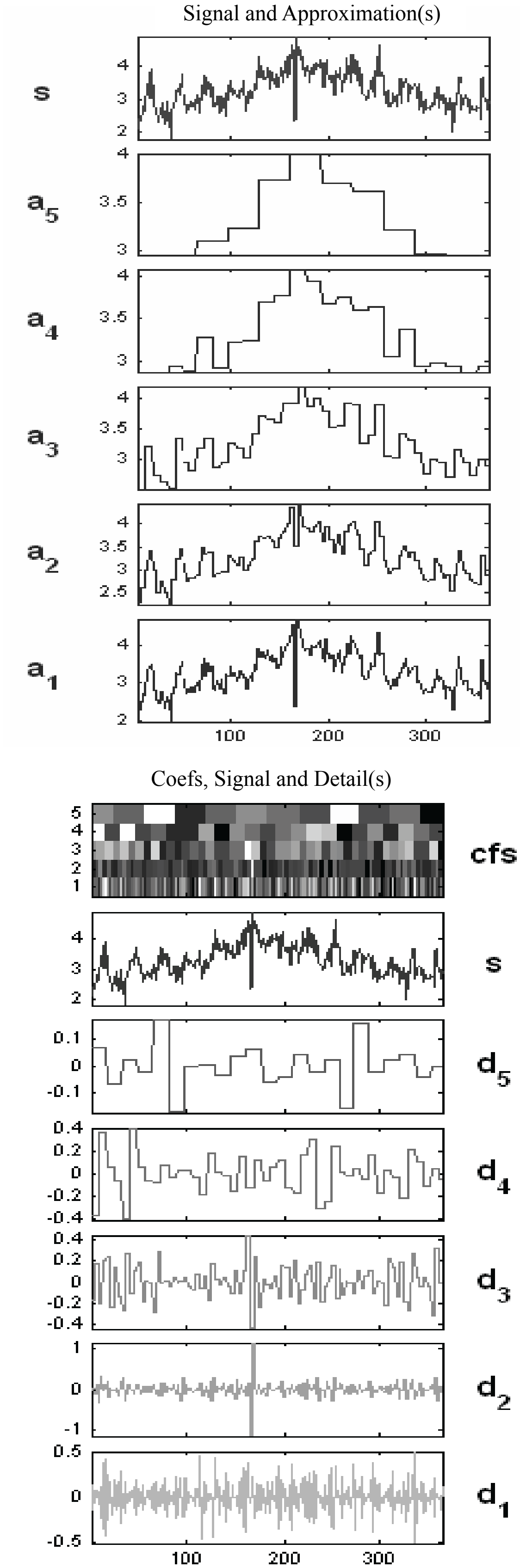

Fig. 4 Wavelet analysis for perturbed parcel velocity of ionospheric region of Pakistan.

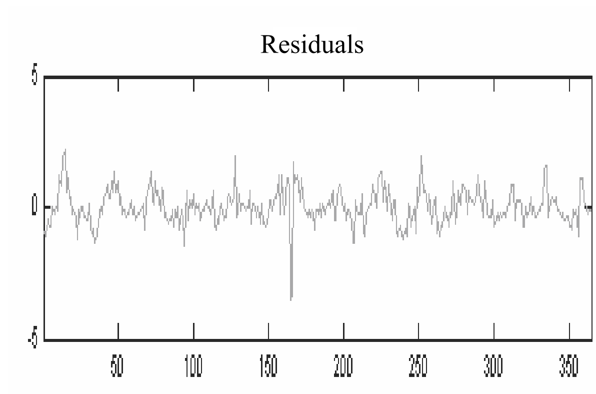

Fig. 5 Manifestation of Residual analysis for un-perturbed parcel velocity of ionospheric layer at Pakistan air space.

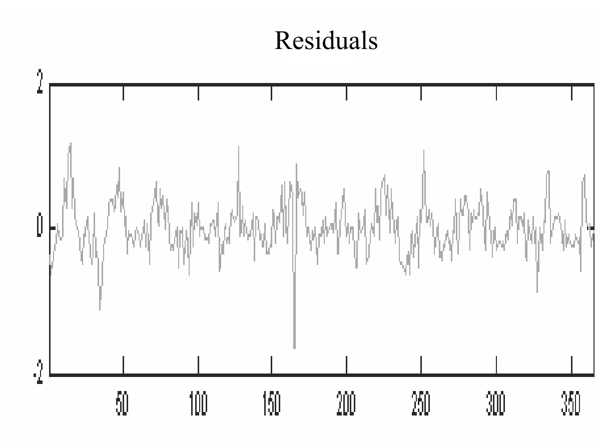

Fig. 6 Illustration of residual analysis for perturbed parcel velocity of ionospheric region of Pakistan.

common method. The Haar wavelet in continuous time series function:

$$f(t) = \begin{cases} 1; & 0 \le t < \frac{1}{2}t_0 \\ -1; & \frac{1}{2}t_0 \le t < t_0 \\ 0; & otherwise, \end{cases}$$

4. CONCLUSIONS

In this work, we have predicted parameters for quantifying the processes and comparing the wavelet characterization of computed perturbed and un-perturbed parcel velocities of ionospheric F_2 layer at the Pakistan air space. We analyzed Spectral analysis, Fast Fourier Transformation and wavelet transformation of one dimension Haar 5-Levels for approximation and detail. The more precise results could be obtained for studying randomness and normality in datasets and these were compared with the datasets for other countries. The results might be useful in understanding astrophysical plasma under varying conditions.

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