GNSS-R DATA PROCESSING SOFTWARE DESIGN FOR THE SEA WIND DETECTION

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Introduction

GNSS-Reflectometry works as a bistatic radar , in which the transmitter and the receiver are separated by significant distance, comparable to the expected distance to the target. Its main principle is to receive and further extract information from the GNSS signals reflected off the Earth surface. A typical GNSS R receiver is placed at the certain distance above the surface can be equipped with two antennas:

1.RHCP antenna (receiving the direct signal)

2.LHCP antenna (reflected signal)

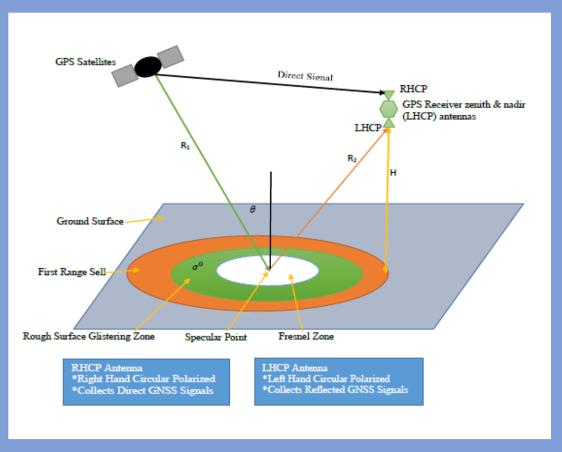

Figure 1.: GNSS-R bi-static radar geometry.

Model

1. Zavarotny Model : .

$$< Z(\Delta_\tau,\Delta_f) > \propto \iint_D \frac{G_r(r)}{R_G^2(r)R_R^2(r)}\frac{q^4}{q_z^4}P\left(-\frac{q^\perp}{q_z}\right) * \Lambda^2(\tau(r)-\Delta_\tau)\theta^2(f(r)-\Delta f)dr$$

Which

r : the spatial coordinate on the sea surface.

Gr : the down-looking antenna gain.

RG and *RR* : the ranges between the sea surface point and the GNSS satellite and receiver.

q : the scattering vector.

P (.) :the probability density function (PDF) of the sea surface slope.

Λ(.) : the auto correlation function (ACF) of the ranging code.

Θ(.) : the frequency modulation function by considering the random distribution of the sea surface height.

2. Elfouhaily Model :

$$\Psi(k,U_{10},\varphi) = \frac{1}{2\pi}k^{-4}[B_1(U_{10}+B_k(U_{10})][B_1(1+\Delta(k,U_{10})\cos(2\varphi)]$$

Which:

B_1 : Long wave curvature spectrum

B_h: Short wave curvature spectrum

Δ : The unified spreading function.

3. Mean square wave slopes [Elfouhaily ,1997 :

$$mss(U_{10}) = \int_0^{k^*}\int_{-\pi}^{\pi} k^2\Psi(k,U_{10},\varphi)d\varphi dk$$

Data

1.Data collection GPS and BeiDou (GEO – MEO) at Shandong Province. Specification data (Table.1):

Table.1 . Specification data

Parameters	Units	Value
RF Frequency	MHZ	1561.098/1575.42
IF Frequency	MHZ	3.996 (BeiDou)
IF frequency	MHZ	4.092 (GPS)
Sampling Rate	MHZ	16.369
Quantization	MHZ	2

2. Experimental Set Up

This campaign aimed to acquire raw samples of direct and reflected GPS and BeiDou signals under different seat state conditions. The chosen site (latitude and longitude 38.1541° ;119.0655 °). The antennas setup is shown in figure 2. below in which observatin point is located about 40m over the mean sea level, LHCP antenna had a slop 45 ° down to the sea surface and azimuth of 210°

Figure 2.: GNSS-R bi-static radar geometry.

Methodology

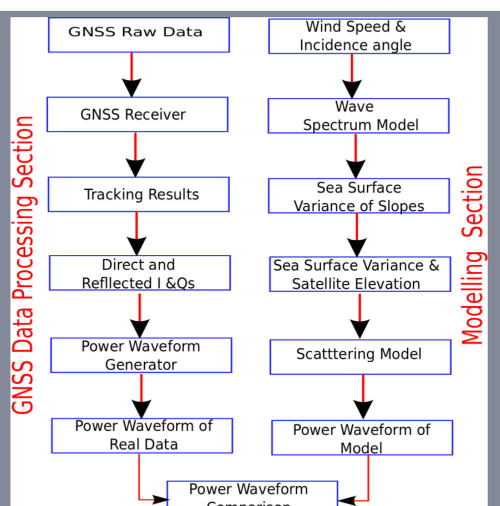

Figure 3: Flow Chart Methodology

Software (GUI)

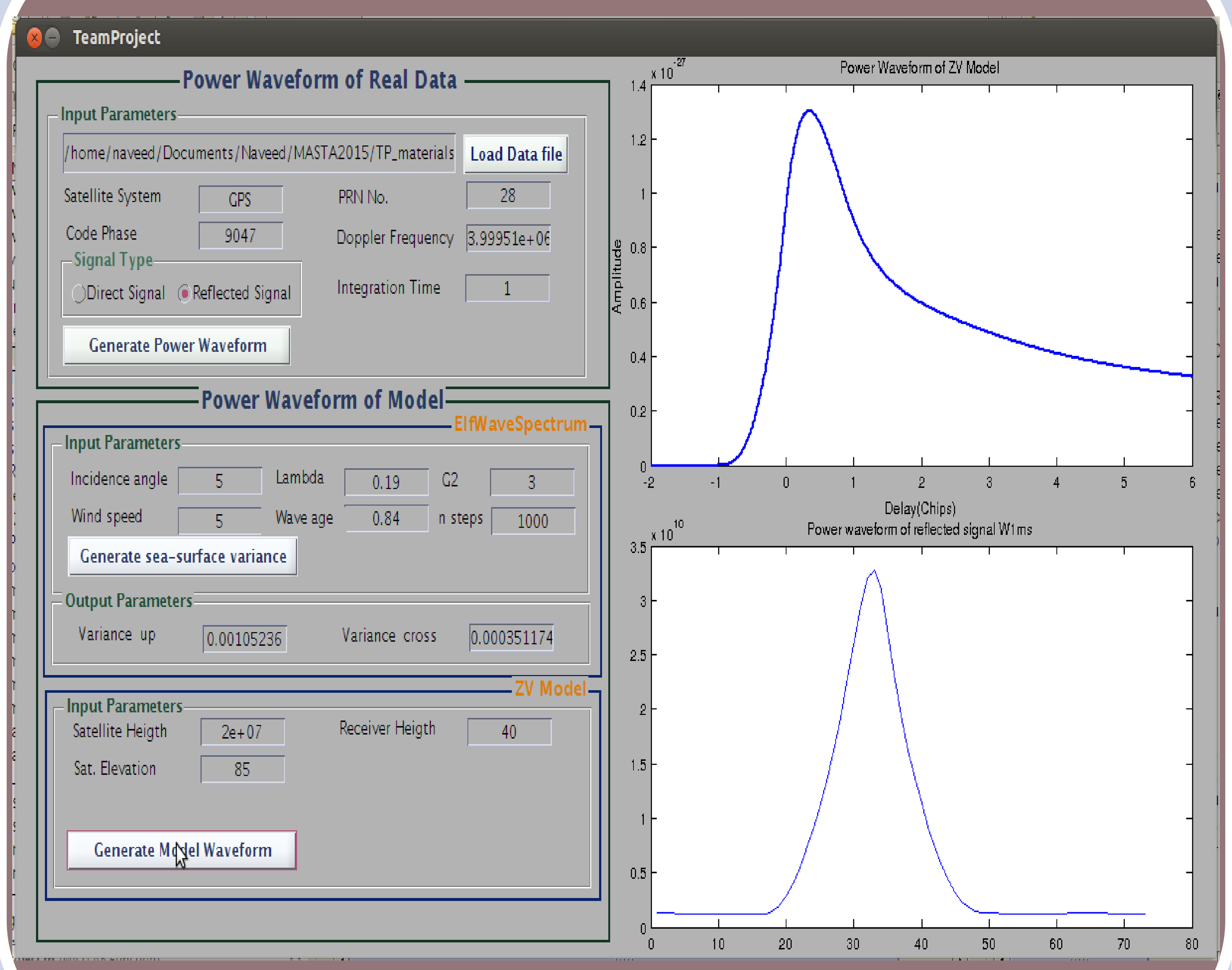

Figure.4. Software GUI

Results and Analysis

1. Results of Power Waveform from Real Data

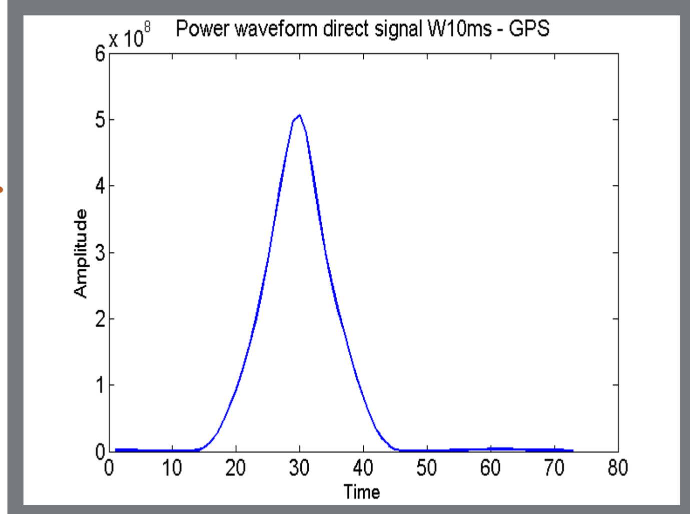

Figure.5(a). Power Waveform reflected signal W10 ms from real data – GPS

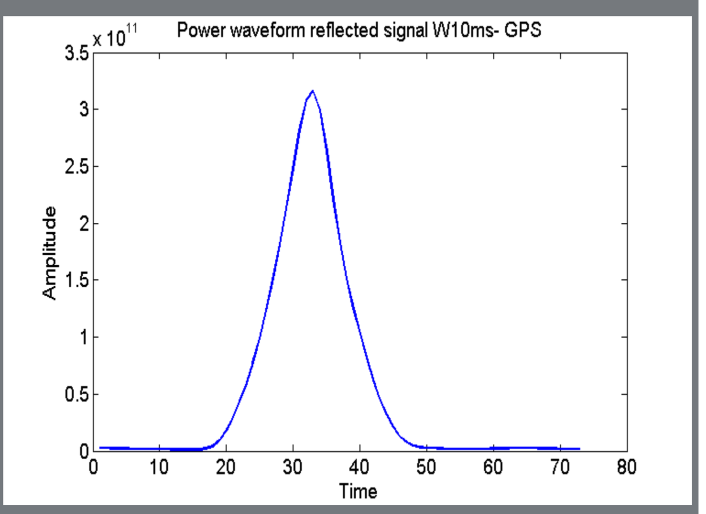

Figure.5(b). Power Waveform reflected signal W10 ms from real data – GPS

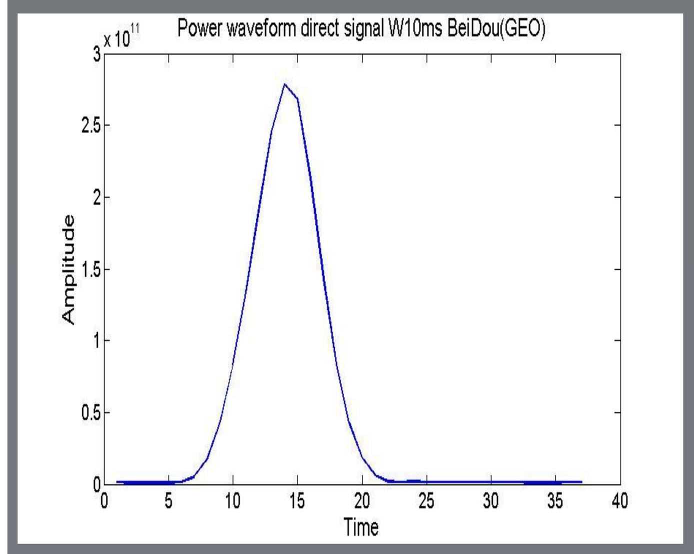

Figure.5(c). Power Waveform direct signal W10 ms from real data – BeiDou (GEO) .

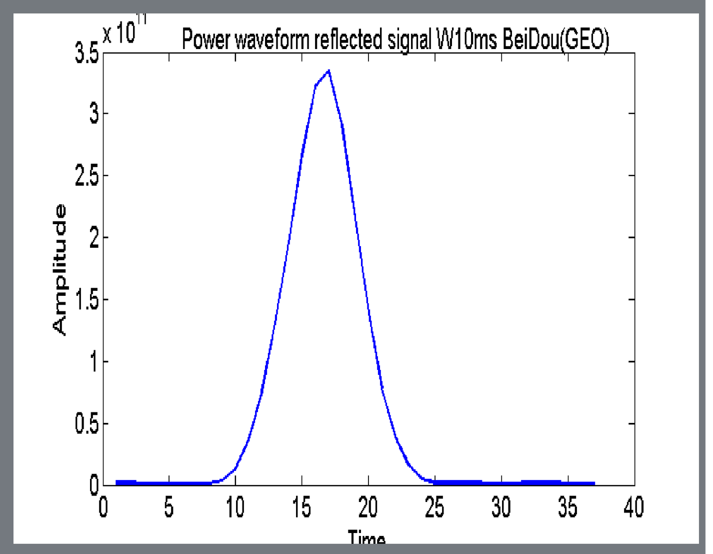

Figure.5(d). Power Waveform reflected signal W10 ms from real data – BeiDou (GEO)

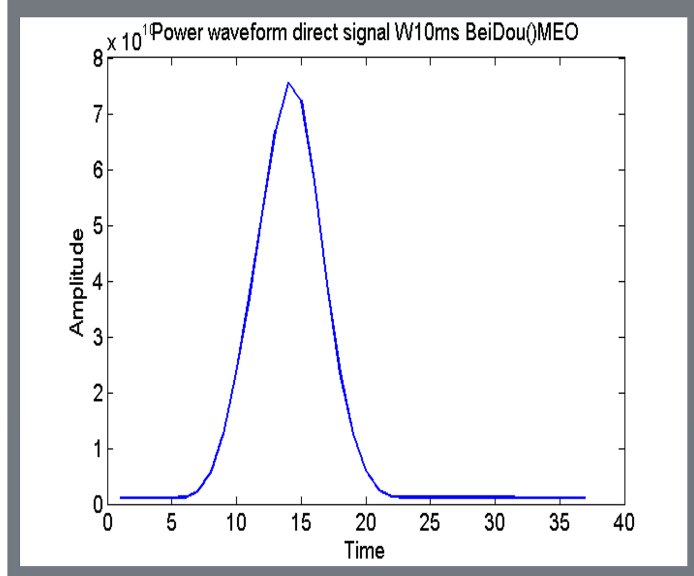

Figure.5(e). Power Waveform direct signal W10 ms from real data – BeiDou (MEO) .

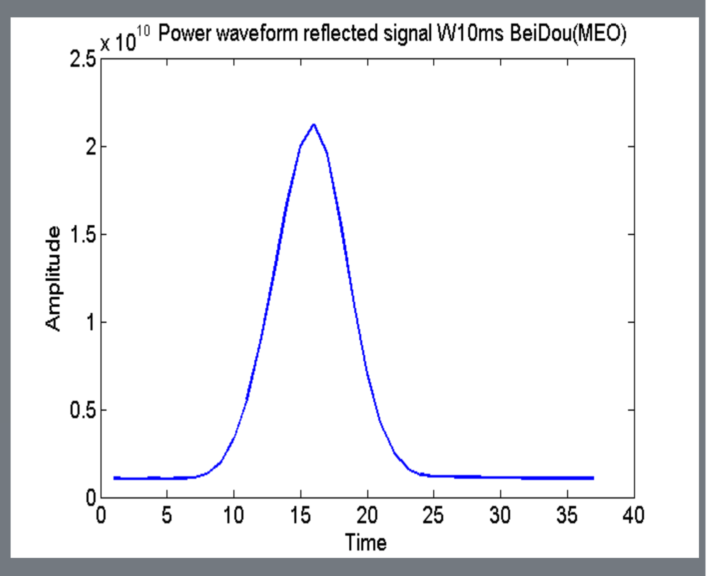

Figure.5(f). Power Waveform reflected signal W10 ms from real data – BeiDou (MEO)

1. We can seen from the figure 5.(a)-(b). Plotting of the comparison between power waveform directed signal and reflected signal to integration time 10ms from GPS real data on 26/08/2015 at almost similar in time delay , the differences between direct and reflected signal is the value of amplitude of power waveform. Amplitude power waveform of direct signal is higher than reflected signal.

2. In figure 5.(c)-(d) shown Plotting of the comparison between power waveform directed signal and reflected signal to integration time 10ms from BeiDou – GEO real data on 26/08/2015 almost similar in time delay.The differences between direct and reflected signal is the value of amplitude of power waveform. Amplitude power waveform of reflected signal is higher than direct signal.

3. In figure 5(e)-(f) shown Plotting of the comparison between power waveform directed signal and reflected signal to integration time 10ms from BeiDou MEO real data on 26/08/2015 almost similar in time delay. The differences between direct and reflected signal is the value of amplitude of power waveform. Amplitude power waveform of direct signal is higher than direct signal.

Results and Analysis

2. Results of Power Waveform- Wind Speed from data & Model

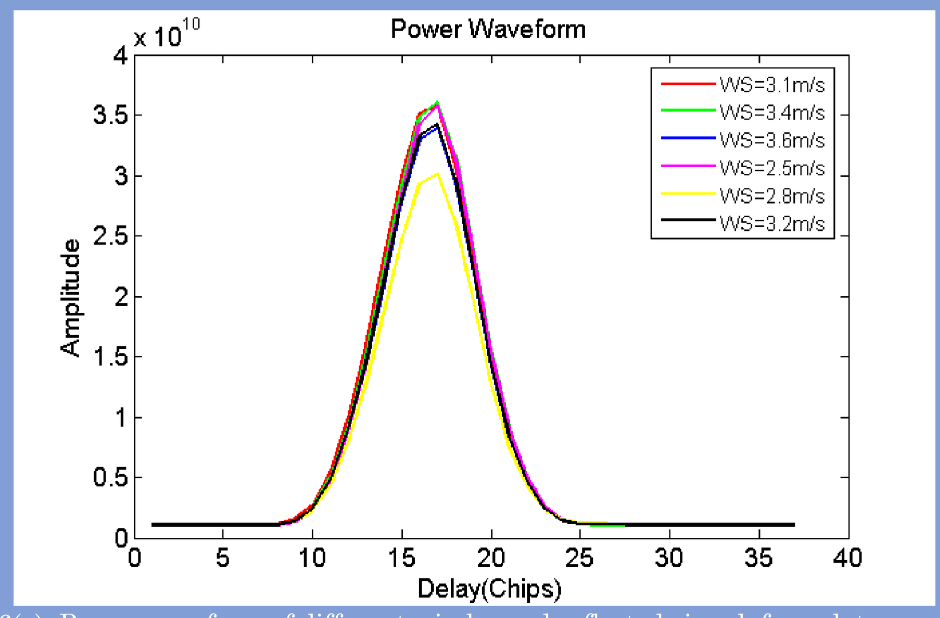

Figure.6(a). Power waveform of different wind speed reflected signal from data

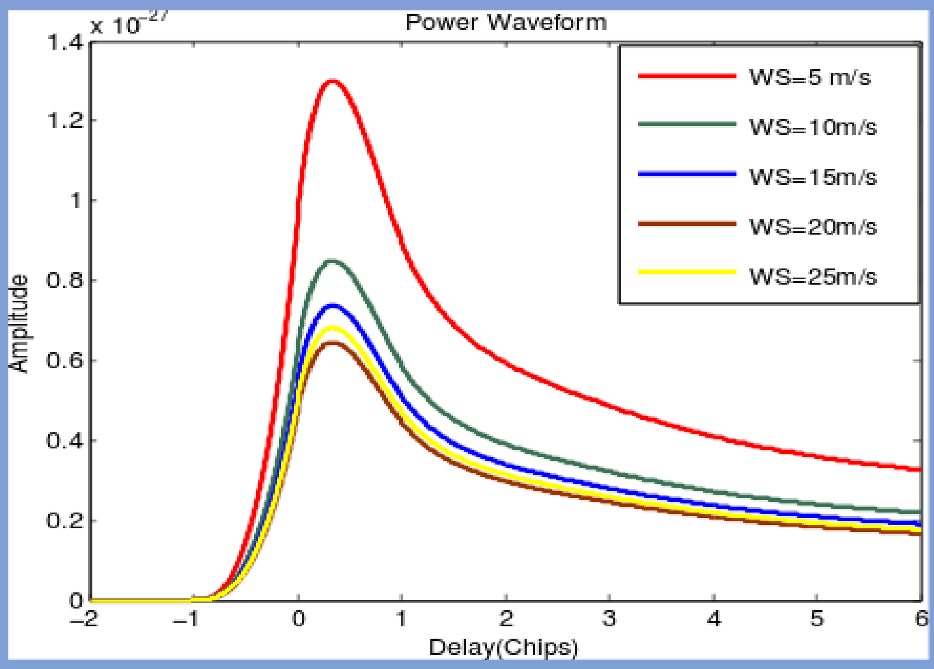

Figure.6(b). Power waveform of different wind speed reflected signal from ZV model

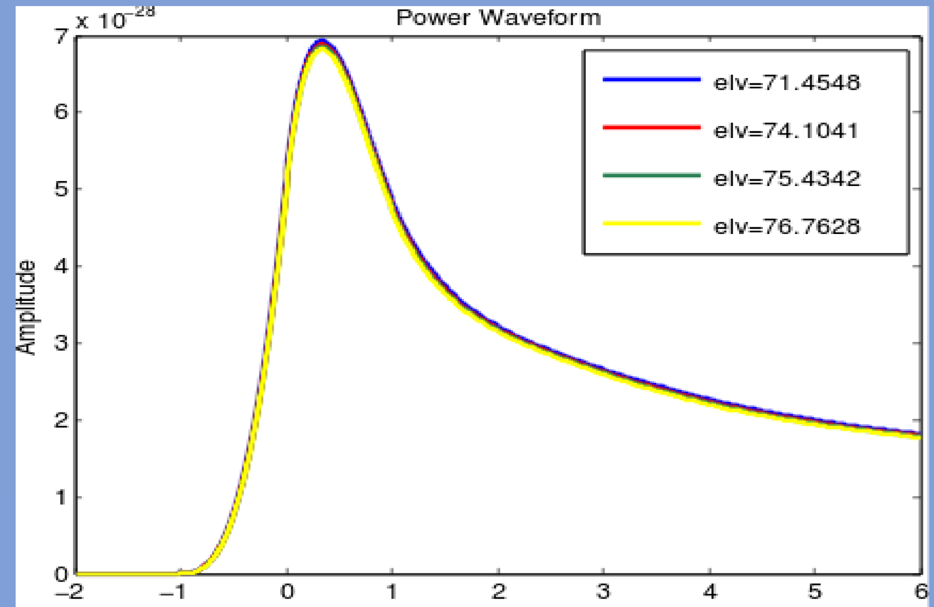

Figure.6(c). Power waveform of different elevation at wind speed 20m/s from ZV model .

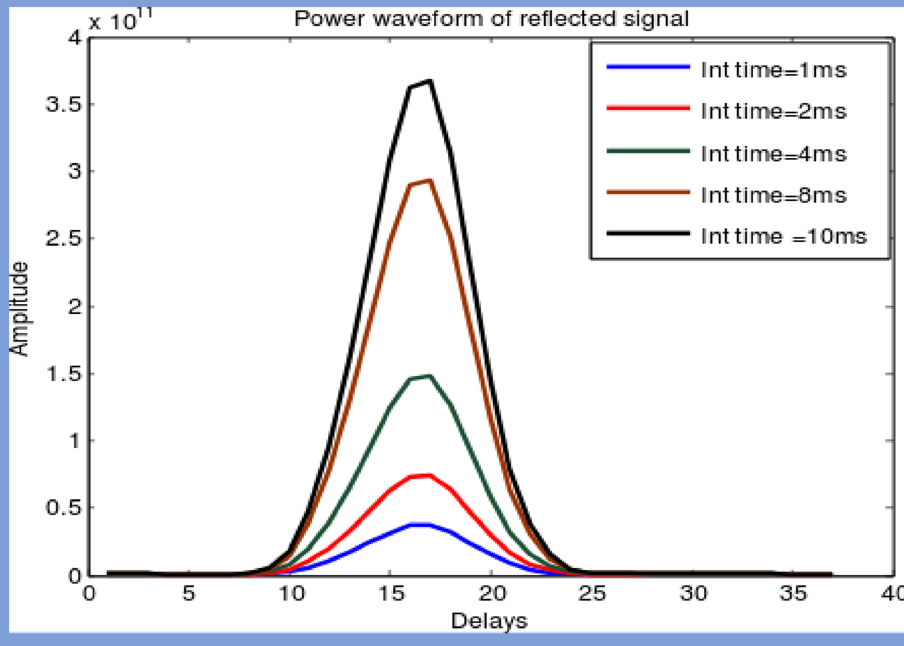

Figure.6(d). Power waveform wind of different integration time

1. The Figure.6(a-d) shown the varies of wind speed of power waveform and different elevation angle and different integration time from real data and ZV model.
2. The results Figure. 6(a-b) show that the model of delay waveforms for a range of wind conditions as it can seen that the higher and narrower peak corresponds to smaller wind speed.

Conclusions

1. This results has presented the processing of sea wind detection using reflected signal of GPS and BeiDou satellite collected at shangdong province.

2. The results of real and modeled data showed that there have correlation between the power waveform at the different delay offset as the function of the wind speed measurement.

3. The results also provides the relationship between the power waveform as the function satellite elevation with constant wind speed.

4. The power waveform remains sensitive to the wind speed which indicates the possibility of wind speed retrieval with the power waveform obtained in our experimental set up.

References

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