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Validation of MST Radar Signals Processed Using HHT with GPS Radiosonde Data

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Abstract: Validation process is been extensively used for checking the accuracy of the results obtained of newly developed algorithms. In the present work, the results obtained by using Hilbert Huang Transform (HHT) techniques for Mesosphere-Stratosphere-Troposphere (MST) radar signals were compared for validation with results of GPS Radiosonde data. The data was collected from National Atmospheric Research Laboratory (NARL), Gadanki. Comparison of U (Zonal velocity) and V (meridional velocity) components was done for validation and the results are plotted. The results showed that the newly developed algorithm using De-noising and HHT techniques was indeed efficient as the average difference of error in the results was very less.Hence, the Hilbert Huang Transform method is one of the best time-frequency analysis method that can be used for processing atmospheric radar signals.

Keywords: MST Radar signals, Hilbert Huang Transform, GPS Radiosonde, Validation.

Introduction

Validation process is used to establish the accuracy of the results obtained in the due course of developing new algorithms using new techniques and further comparing them with the existing methods. In the present work, the results obtained by using Hilbert Huang Transform (HHT) techniques for MST radar signals were compared for validation with results of GPS Radiosonde data. The data was collected from National Atmospheric Research Laboratory, NARL, Gadanki.

MST Radar Signal Processing

A. Hilbert Huang Transform

Analysis of radar signals is very useful for analysis of atmospheric layers. HHT is the one of the method for analysis of non-stationary and non-linear signals [2]. The Hilbert Huang Transform (HHT) is an empirically based data- analysis method proposed Norden E. Huang in 1996. HHT can be used for processing nonstationary and nonlinear signals from which, it can produce physically meaningfulrepresentations, especially for time-frequency-energy representations. The Hilbert Huang Transform consists of both Empirical Mode Decomposition and Hilbert Spectral Analysis.

The HHT uses EMD method to decompose a signal into Intrinsic Mode Functions (IMF) with a trend, to obtain instantaneous frequency data by applying Hilbert Spectral Analysis (HSA) method to the IMFs. The HHT has the characteristic of varying frequency because the IMFs are same. [1]The decomposition of IMFs are in time domain and length of the signal.HHT can lead the time- frequency-energy of time series. Moreover, EMD results inextraction of IMFs on which various de-noising techniques can be applied for accurate detection of the Doppler echo. This is an important advantage of HHT. [18] EMDhas a wide range of applications in signal processing and allied fields. Its basis of expansion is adaptive.The algorithm uses EMD de-noising using soft thresholding techniques for accurate Doppler profile detection and Signal toNoise Ratio (SNR) improvement of MST Radar Signals [17]. Algorithm was applied on MST radar data which was collected from NARL (National Atmospheric Research Laboratory), Gadanki, India. The algorithm was tested for its efficacy on various data sets for all the 6 beams.

B. GPS Radiosonde

In the atmosphere GPS Radiosonde measures the parameters and transmits them by radio to a ground receiver. The variables like altitude, pressure, temperature, relative humidity, both wind speed and wind direction, cosmic ray readings at high altitude, Latitudeand Longitude are calculated and measured by Radiosonde. At NARL, the RD-11G Upper Air Observing System consists of a radiosonde receiving antenna system, GPS receiving antenna, GPS Sonde Receiver, and the data processor, PC computer which is connected to a networking subsystem via a TCP/IP. Through this system the radiosonde data was collected.A GPS section permits precise observation from ground to the stratosphere, it improves the elimination of the pressure sensor from radiosonde.

Usually, a radiosonde is a battery power telemetry instrument which is carried in to the atmosphere by a weather balloon. In the atmosphere it measures the parameters and transmits them by radio to a ground receiver. The variables like altitude, pressure, temperature, relative humidity, both wind speed and wind direction, cosmic ray readings at high altitude, Latitude andLongitude are calculated and measured by Radiosonde [6].

The frequency range of radiosonde is about 403 MHz to 1680 MHz, The wind speed and wind velocity information obtained from the radiosonde is called rawinsonde [10]. The GPS radiosonde data was collected from NARL, Gadanki, Tirupati Comparison of U (Zonal velocity) and V (meridional velocity) components was done for validation and the results are plotted. For the process of validation.

Validation Process

The MST radar data and GPS radiosonde data for the same days was collected from NARL, Gadanki, Tirupati. The U (Zonal velocity component) and V (Meridional velocity component)obtained using HHT techniques are the compared with that obtained using GPS Radiosonde data. The U and V components obtained using HHT extended up to 25.95 Km. The results obtained from the GPS Radiosonde contains the variables like altitude, pressure, temperature, relative humidity, both wind speed and wind direction, cosmic ray readings at high altitude, Latitudeand Longitude. By pre-processing the GPS radiosonde data with respect to MST radar data, the data for comparison is assessed. The numerical values from 3.6 to 25.95 km height were considered for analysis for both MST radar and GPS radiosonde data for 150 range bins. During pre-processing, the wind speed and wind direction are taken as key parts to evaluate the U and V components of velocity as shown below.

U=-(Wind speed.*Sind (Wind direction)) --------- (1)
V=-(Wind speed.*cosd (Wind direction)) --------- (2)

By considering the equations (1) and(2), the pre-processed data of GPS radiosonde data is estimated. Further by simple comparison plot, the values of zonal velocitycomponent (U) and the meridional velocitycomponent (V) of both MST radar and GPS radiosonde data were compared for validating.

Results

The MST Radar data and GPS Radio Sonde data for the same dates were collected from NARL, Gadanki for the process of validation. The results of data sets for 1st July 2014, 8th July 2014 and 10th February2015 were considered for analysis and the results are plotted. The zonal velocity component (U) and the meridional velocity component (V) calculated forMST radar and GPS radiosonde data were plotted for comparison. The figures 1(a) and 1(b) shows the comparison plot of U's (Zonalvelocity) component of 1st July 2014. Figures 1(c) and 1(d) represents the difference between zonal and meridional velocity components of 1st July 2014 using MST radar and GPS radiosonde data.Similarly, the figures 2 (a) and 2 (b) shows the comparison plot of U's (Zonal velocity) component of 8th July 2014. Figures 2(c) and 2 (d) represents the difference between zonal and meridional velocity components of 8th July 2014 using MST radar and GPS radiosonde data.Figures 3 (a) and 3 (b) shows the comparison plot of U's (Zonal velocity) component of 10th February 2015. Figures 3 (c) and 3 (d) represents the difference between zonal and meridional velocity components of 10th February 2015 using MST radar and GPS radiosonde data.

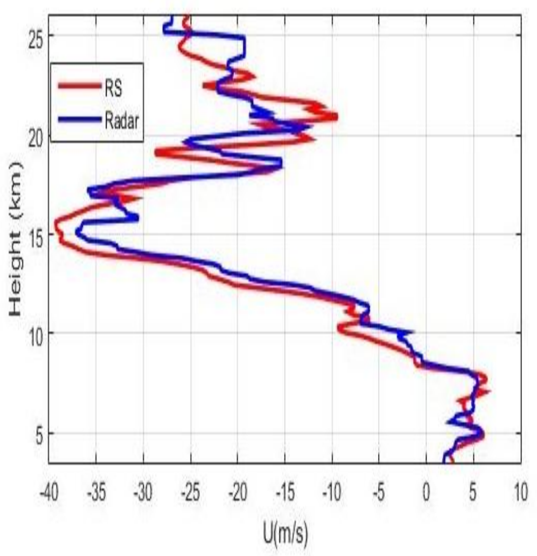


Figure 1(a): Zonal velocities of MST radar And GPS radiosonde of 1st July 2014

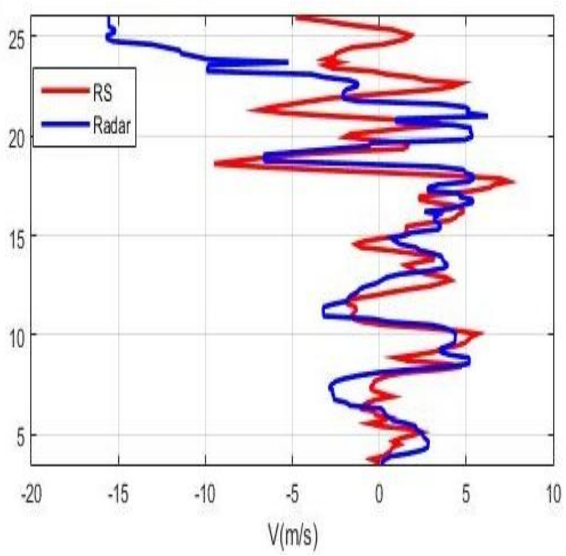


Figure 1(b): Meridional velocities of MST radar And GPS radiosonde of 1st July 2014

(Data in meters per seconddata in meters per second)

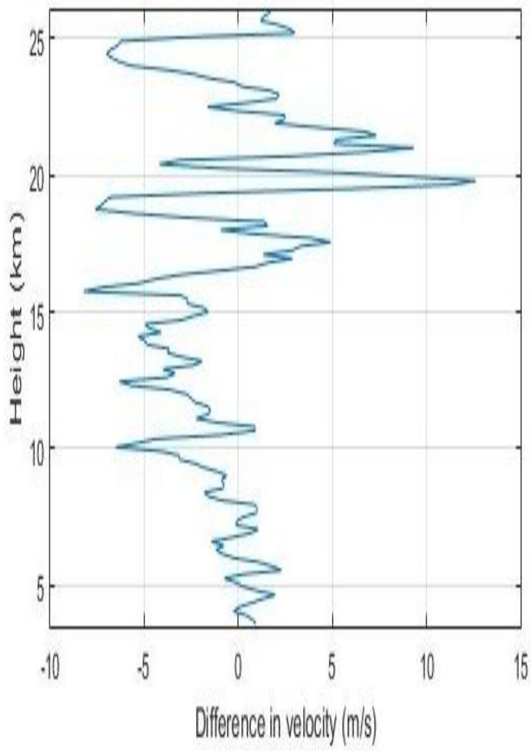


Figure 1(c): Difference between zonal velocities of MST radar data and GPS radiosonde of 1st July 2014

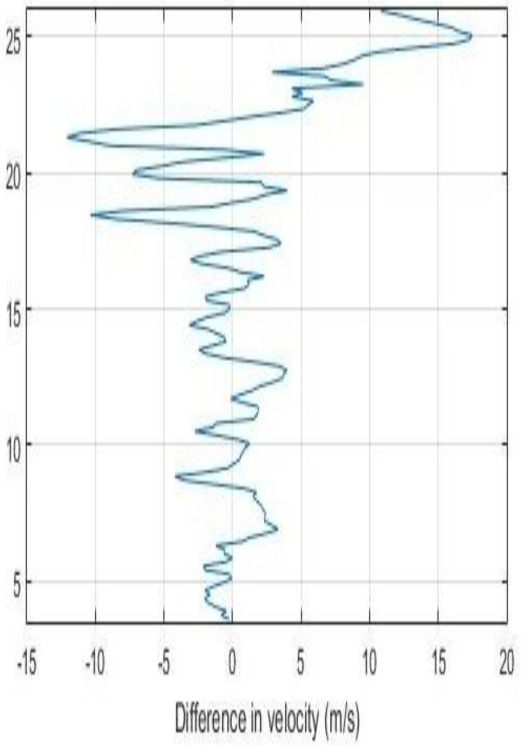


Figure1(d): Difference between meridionalvelocities of MST radarand GPS radiosonde of 1st July 2014

(Data in meters per seconddata in meters per second)

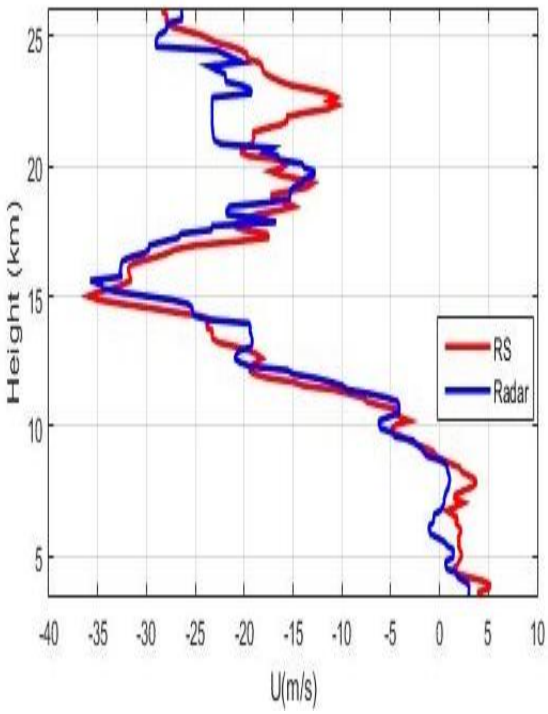


Figure 2(a): Zonal velocities of MST radar and GPS radiosonde of 8thJuly 2014

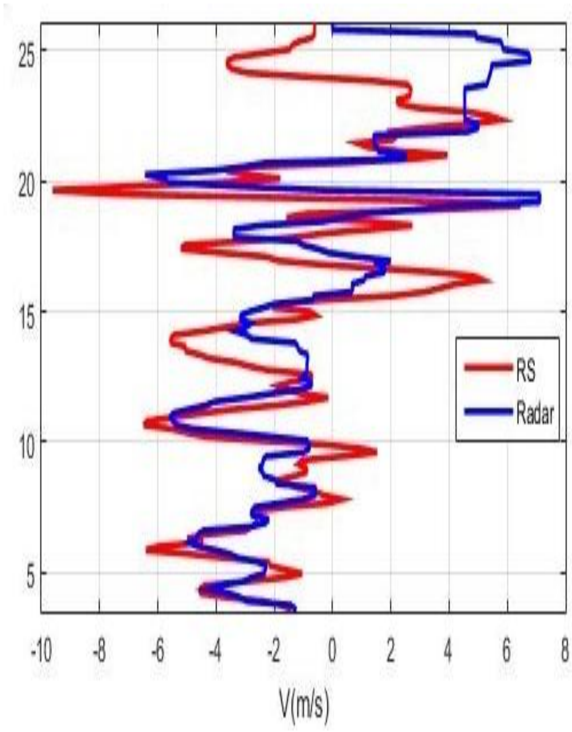


Figure2(b): Meridional velocities of MST radar and GPS radiosonde of 8th July 2014

(Data in meters per second)

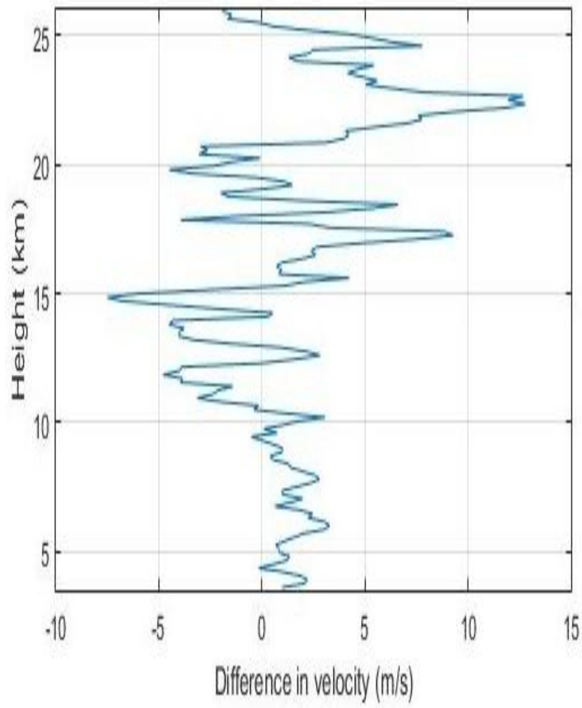


Figure 2(c): Difference between zonal velocities of MST radar data and GPS radiosonde of 8th July 2014

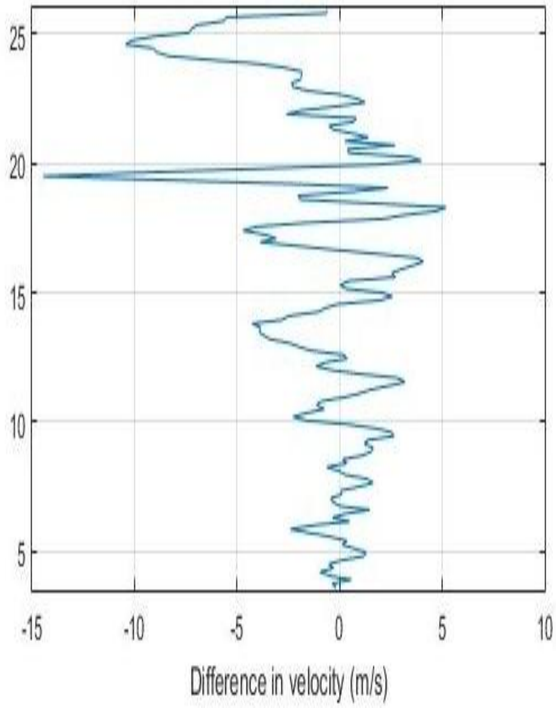


Figure2(d): Difference between meridionalvelocities of MST radarand GPS radiosonde of 8th July 2014

(Data in meters per second)

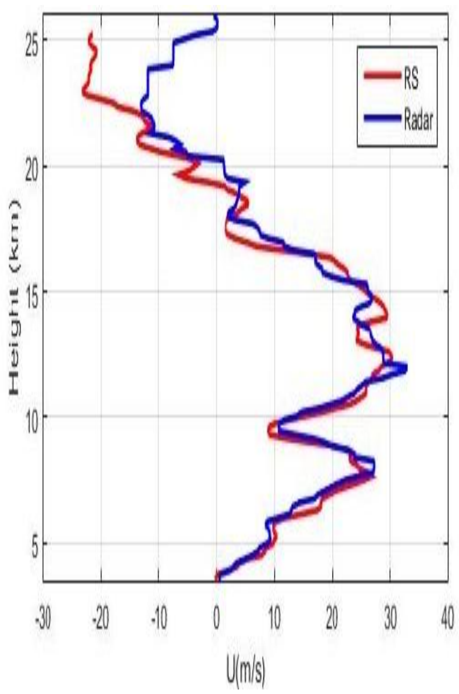


Figure 3(a): Zonal velocities of MST radar And GPS radiosonde of 10th February 2015

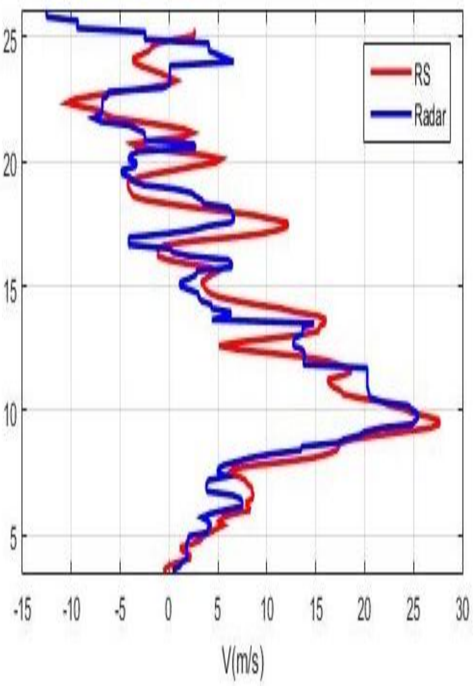
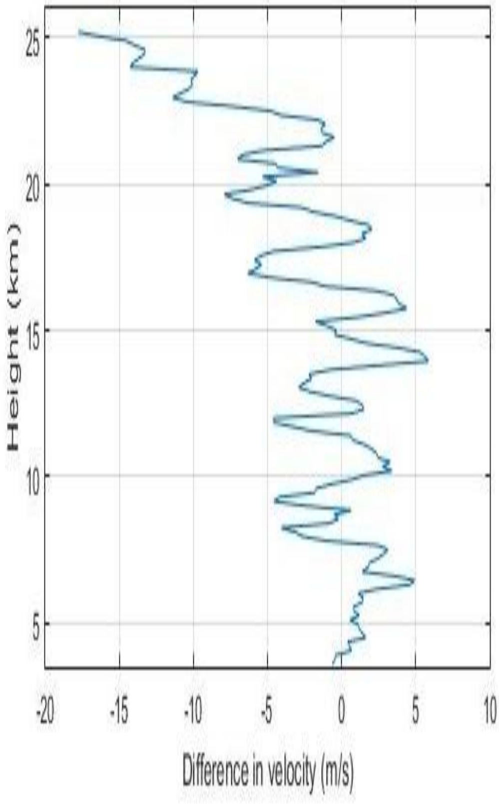


Figure3(b): Meridional velocities of both MST radar And GPS radiosonde of 10th February 2015

(Data in meters per second)



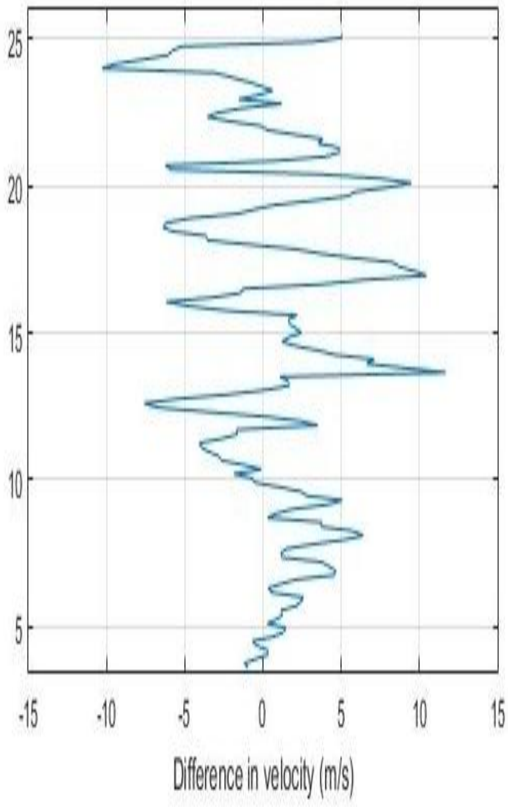


Figure 3(c): Difference between zonal velocities of MST radar data and GPS radiosonde of 10th February 2015

Figure3(d): Difference between meridionalvelocities of of MST radar and GPS radiosonde of 10th February 2015

(Data in meters per second)

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Conclusion

Validation of the results obtained from the both MST radar and GPS radiosonde was done for three different data sets for the same days. Hilbert Huang Transform techniques were used to process MST radar signals and the U (zonal velocity) component andV (Meridional velocity) component were compared with that of GPS Radiosonde data. It has been observed from the results that both the U and V velocity components obtained using both the methods are approximately the same. Also the average difference in the calculation of the U (zonal velocity) component for the data sets of 1st July 2014, 8th July 2014 and 10th February 2015 are -0.82 meters per second, 1.39 meters per secondand -2meters per secondrespectively and V (Meridional velocity) component are 1.085 meters per second, -0.88 meters per second and 0.79meters per second respectively. It is evident from the results of validation that the newly developed algorithm using de-noising and HHT techniques was accurate as the average difference of error in the results was very less.

References

[1] Woodman, R.F., "Spectral moments estimation in MST radars," Radio Science., Vol.20, pp 1185-1195, 1985.

[2] Anandan, V.K., Balamuralidhar, P., Rao, P.B., Jain, A. R. and Pan, C. J.: "An Adaptive Moments Estimation Technique Applied to MST Radar Echoes," Journal of Atmospheric and Oceanic Technology, Volume 22.2004.

[3] Padmaja, N., Varadarajan, S. and Swathi, R.: "Signal Processing of Radar echoes using Wavelets and Hilbert Huang Transform," Signal & Image Processing: An International Journal (SIPIJ) Vol.2, No.3, September 2011

[4] Morse, C. S., Goodrich, R.K. and Cornman, L.B.: "The NIMA method for improved moment estimation from Doppler spectra," J. Atmos. Oceanic Technol., 19, 274–295, 2002.

[5] Padmaja. N., Bharathi, M., and Sujatha, E. (2016). A GUI based EEG Signal De-noising using Hilbert Huang Transform. i-manager's Journal on Electronics Engineering, 7(1), 25-30. https://doi.org/10.26634/jele.7.1.8281

[6] F. Heymann, J. Hoth, P. Banyś& G. Siegert, "Validation of Radar Image Tracking Algorithms with Simulated Data", the International Journalon Marine Navigation and Safety of Sea Transportation, September 2017

[7] Ramyakrishna, E., T. Narayana Rao, and N. Padmaja. "Development and Evaluation of Automated Algorithm for Estimation of Winds from Wind Profiler Spectra." Advances in Signal Processing and Intelligent Recognition Systems. Springer, Cham, 2016. 473-483.

[8] Patnaikuni ChandanaKumari, Dr. N. Padmaja, "Compare the Performance Analysis for HHT Based MIMO OFDM with DWT Based MIMO-OFDM", International Journal of scientific engineering and technology research.

[9] Padmaja, N & D. V. Subba Rao, Ch & Ramakrishna, G. (2017),"Analysis of Teager Energy Estimation using TEO and HHT". 397-401. 10.1145/3176653.3176670.

[10] Makoto FUJITA, Hideki MASUYAMA, Naoki KANEKO, and Hiroshi KANEKO," Differential GPS Radiosonde Observation System", Meisei Electric Co., Ltd., Japan.

[11] Huang, N. E., and Z. Wu (2008), A review on Hilbert-Huang transform: Method and its applications to geophysical studies,Rev. Geophys.46, RG2006, doi: 10.1029/2007RG000228.

[12] Jing-tian, T., Qing, Z., Yan, T., Bin, L. and Xiao-kai, Z.: "Hilbert Huang Transform forECG de-noising," 1st International Conference on Bioinformatics and BiomedicalEngineering, 2007.

[13] Scott T. Smith, "Matlab Advanced GUI Development", Dog Ear Publishing, 2006.

[14] Sanjit K Mitra, "Digital signal processing, A computer base approach", McGraw-Hill Higher Education, 4th edition, 2011.

[15] Susan Wooldridge," Data Processing", Made Simple, 1976.

[16] He You, XiuJianjuan, Guan Xin,"Radar Data Processing with Applications", 2016 Publishing House of Electronics Industry.

[17] Norden E Huang and Samuel S P Shen,"Hilbert-Huang Transform and its applications".

[18] Huang, et al. "The empirical mode decomposition and the Hilbert spectrum for nonlinear and non-stationary time series analysis." Proc. R. Soc.Lond. A (1998) 454, 903–995.