A Physical Study of River RamGanga by using Complex Morlet Wavelets

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Abstract: Wavelets provide local information about data in time and scale (frequency), wavelet-based coherence allows to measure time-varying correlation as a function of frequency. In other words, a coherence measure suitable for nonstationary processes. Time Frequency analysis is an important tool in modern signal analysis. In this paper, we analyze the relationship between different time series after distributing their energies in both time and frequency domain. Wavelets have the special ability to localize the signal in both time and frequency domain simultaneously. By using this ability, we perform an analytical framework for modeling the statistical behavior of physical parameters of river water such as Width, Velocity and depth. For this purpose, we used 'cmor1-1' wavelet of complex Morlet family. Physical parameters of river water are taken from river Ramganga of the time period 2005-2008. CWT of two time series and the cross examination of the two decompositions can reveal localized similarities in time and scale. The magnitude of the wavelet cross spectrum (Wcs) can be interpreted as the absolute value of the local covariance between the two time series in the time-scale plane.

Keywords: cmor1-1, CWT, River Ramganga, Time frequency domain, Wcs.

1. INTRODUCTION

In India, a number of studies have been made to describe the hydrochemistry of several stream and rivers. Kulwinder Singh Parmar et al. [1] studied the water quality parameters by using Daubechies wavelet (db5). Also the impacts of hydrological conditions of the water on biological community of the water body have been documented (Pathak et al.) [2, 3, 4]. Due to limited and confined study of river water, interpretations of the quality of surface water are incomplete for taking any measure for sustainable development4. The quality of river water is depleting rapidly with the change in human life style i.e., massive industrialization, construction activities, and other developmental purposes. Most of the surface water studies focus on the assessment of quantitative sources and on the identification recharge processes. The rapid industrialization and expansion of cities poses high pressure on water resources including surface water, results their depletion and contamination. In India as a developing country, industrial pollution is one of the main causes of water pollution has been investigated in several major rivers. The necessity to efficiently conserve and manage freshwater resources is becoming more and more urgent. This is as a result of growing world population and economic activities with

the subsequent degradation of freshwater resources as a result of anthropogenic pollution. To sustainable manage freshwater ecosystems an understanding of the basic physical, chemical and biological components, their functions and interrelationship is necessary. Therefore, it is necessary to monitor and evaluate water quality on regular basis.In this article an attempt has been made to evaluate the selected parameters by applying wavelet analysis technique to diagnose the water quality problems.

2. STUDY AREA

River Ramganga, is the most important tributary of holy river Ganga, is spring fed originated from the southern slopes of Dudhatoli of middle Himalaya of Uttrakhand state. The river enters the plains at Kalagarh where a famous hydroelectric earthen dam has been constructed in 1975. The river traverses near about 158 km before it meets the reservoir and continues to downstream for about 370 km before joining river Ganga at Kannauj of Uttar Pradesh. The study area of the river catchment lies between north latitude 29°29'42" and 28°49'32" and east longitude 78°45'37" and 78°47'53.

Figure 1: Downstream River Ramganga, situted in moradabad city of India

3. EXPERIMENTAL ARRANGEMENT

In order to carry out in depth investigation, nine sampling stations at different segments of river Ramganga were selected on the basis of varied topographical conditions, agricultural, social pattern and on the locations of various large and small-scale industries and also on the basis of human settlement.

Sampling Spots in downstream River Ramganga are : 1 Kalagargh 2 Bhutpuri 3 Seohara 4 Mishripur 5 Agwanpur 6 Jigar Colony 7 Lalbhagh 8 Jamamasjid 9 Kathgargh In order to select suitable sampling sites, a preliminary survey was conducted to determine various land use patterns.

4. WAVELET ANALYSIS

Wavelet analysis is new development in the emerging field of data analysis [6, 8, 9]. It represents an efficient computational algorithm under the interest of a broad community. Fourier sine's extracts only frequency information from a time signal, thus losing time information, unlike Fourier transform wavelet extracts both time evolution and frequency composition of a signal [7].

Actually, Wavelet transform is simply a correlation between a given signal to a given wavelet function. Wavelet function is a special kind of a function which is satisfy two wavelet admissible conditions

$$C_\psi = \int_0^\infty \frac{\left|\hat{\psi}(\omega)\right|}{\omega} d\omega < \infty \tag{1}$$

where $\hat{\psi}(\omega)$ is Fourier transform of wavelet function $\psi(\omega)$ and

$$\int_0^{\infty} \psi_{a,b}(t)dt = 0 \tag{2}$$

Waveletsare a special kind of functions which exhibits oscillatory behavior for a short period of time and then die out. For any two real numbers *a* and*b*, a wavelet function is defined as:

$$\psi_{a,b}(t) = \frac{1}{\sqrt{a}}\psi\left(\frac{t-b}{a}\right) \tag{3}$$

where*a* is scaling parameter which gives the dilate or compressed version of wavelet function and b is a parameter gives a translated version of wavelet function called translation parameter.

Wavelets are introduced as basis functions by which time resolution must increase with the central frequency of the analysis filters. They satisfy the Heisenberg inequality, but the time resolution becomes arbitrarily good at high frequencies, while the frequency resolution becomes arbitrarily good at low frequencies.

4.1 Complex Morlet Wavelet: Cmor1-1 wavelet is an infinite bandwidth wavelet function of complex Morlet wavelet family. Mathematically, a Complex Morlet Wavelet is defined as,

$$\psi(x) = \frac{1}{\sqrt{b}f_b} e^{2\pi i f_c} e^{x^2/f_b} \tag{4}$$

Depending on two parametersf_b and f_c , where f_b is bandwidth parameter and f_c is wavelet central frequency.Figure 2 shows real and imaginary parts of complex Morlet wavelet. In MATLAB prompt it can be easily found by command

[Psi,X]=cmorwavef(LB,UB,N,FB,FC)

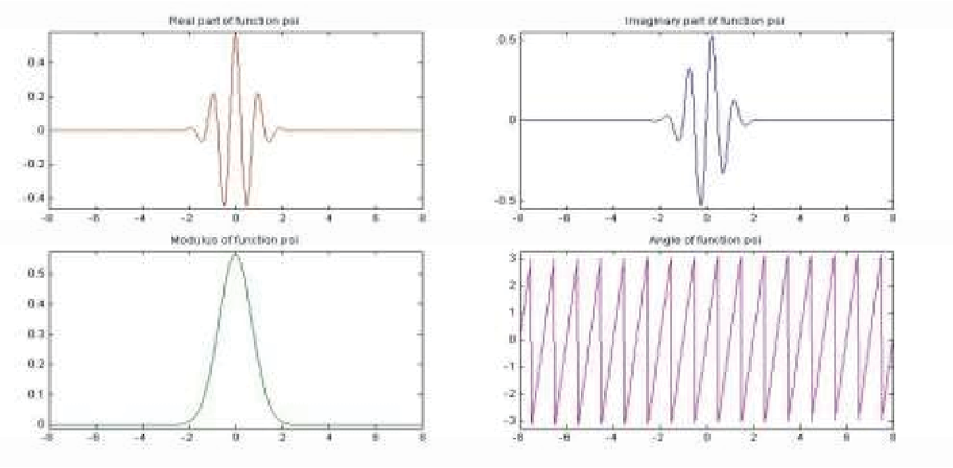

Figure 2:Real and Imaginary Parts of Complex Morlet Wavelet function

5. ANALYTIC APPROACH AND RESULTS

In order to perform a more detailed investigation, we perform a continuous wavelet transform of the time series of velocity, depth and width of river and calculate the wavelet coefficients.

For this purpose, we used the cmor1-1 wavelet transform. Scalograms of all-time series are performed by choosing scale levels from 1 to 64 with a sampling period 1 andcolormap jet. Scalograms of the river water parameter are shown in figure 3, figure 4 and their relative wavelet cross spectrums in shown in figure 5 and 6 respectively.

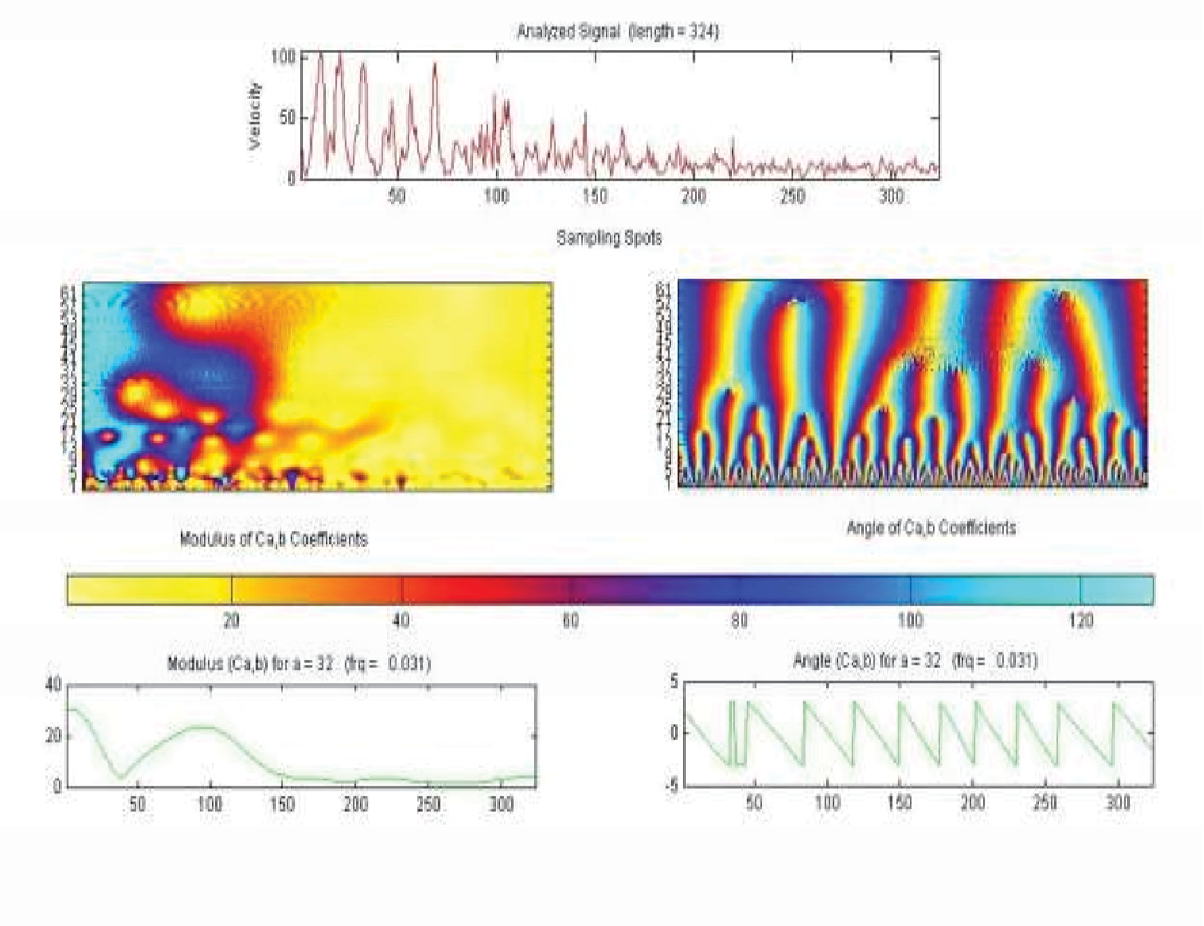

Figure 3: 3 years original data of velocity of river water with its scalograms.

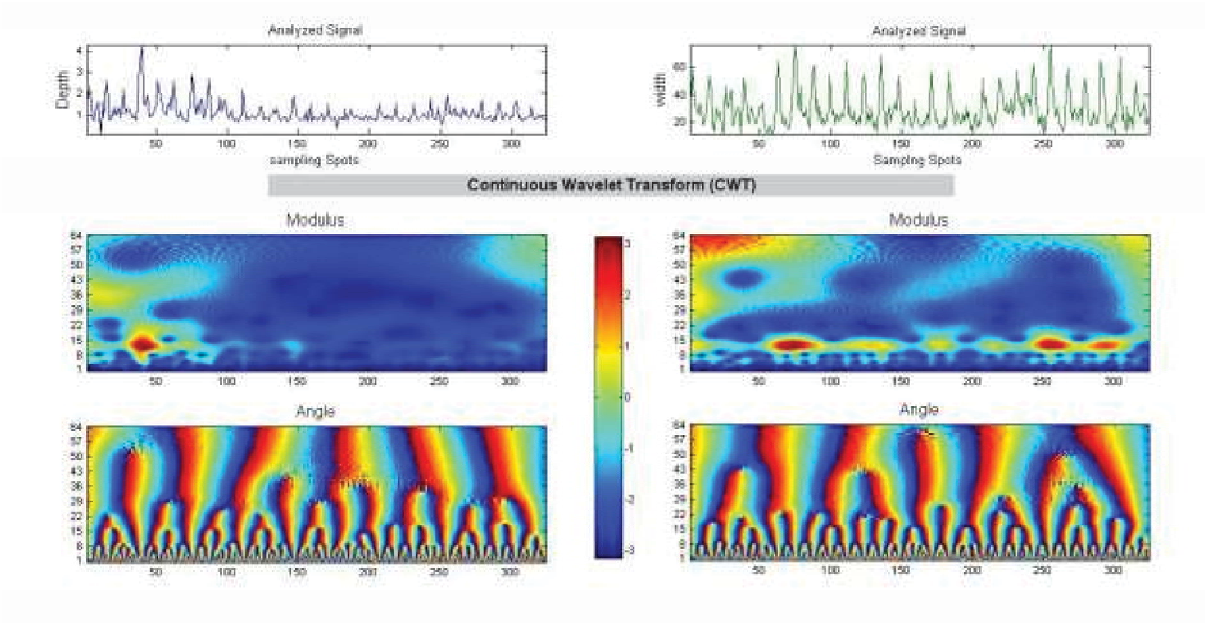

Figure 4: 3 years original data of river depth and river width and its cwtscalograms

These graphs show localized similarities in time and scale. The magnitude of the wavelet cross spectrum (Wcs) give the absolute value of the local covariance between the time series in the time-scale plane.

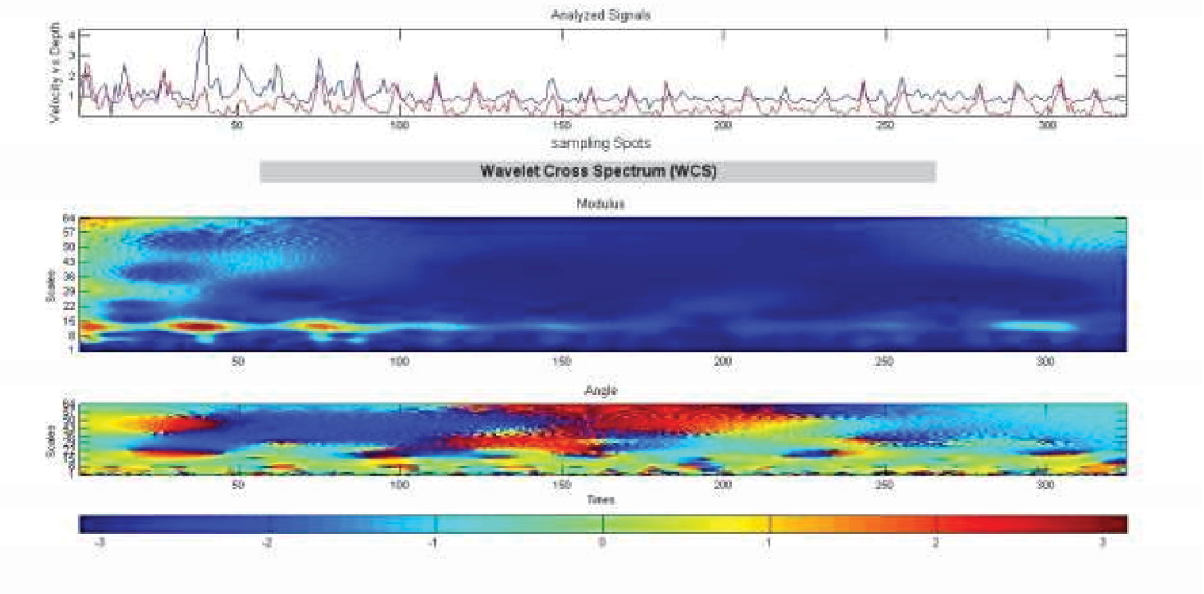

Figure 5:wavelet based coherence between time series V and D

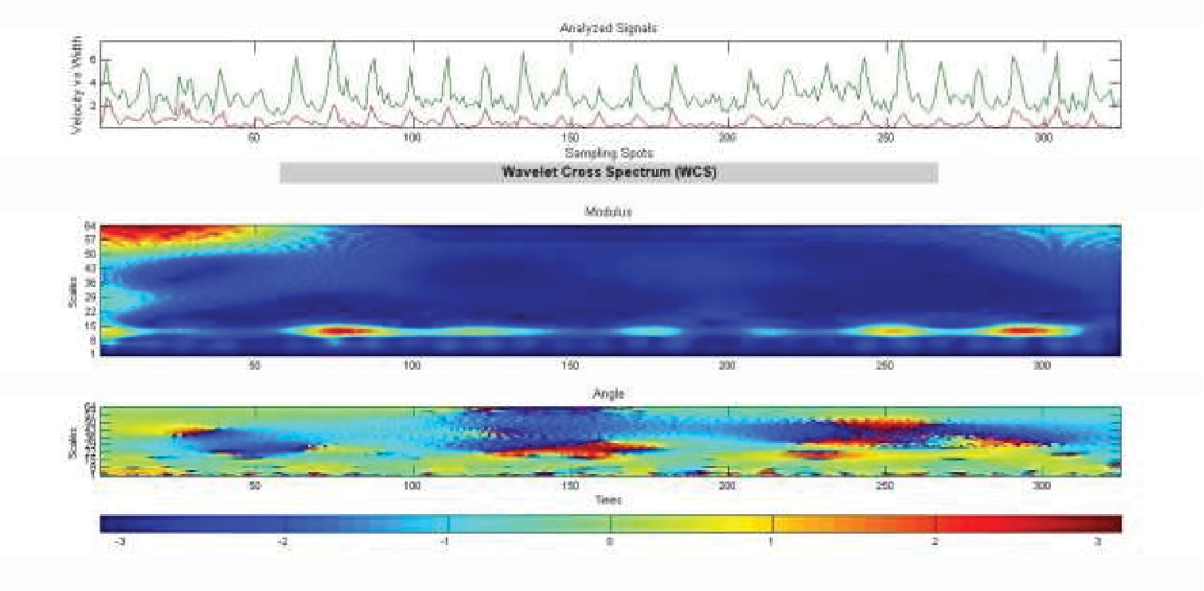

Figure 6: wavelet based coherence between time series V and W.

6. CONCLUSION

We have analyzed the time series V, D,W for the time period 2005-2008. According to the behavior studied above, Wavelet analysis of selected water quality parameters make it possible to quantify the variations on a particular time frame and variations and interrelationships existing between natural and anthropogenic interferences of water quality indicators. The Complex morlet wavelet method allows the decomposition of signal according to different frequency levels which characterise the intensity of natural and man-made disturbances. There is very few literature is available on application of wavelet in hydrochemisry, a detailed study is required to improve the modeling and management of lotic as well as lentic water bodies.

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References:

[1] S. G. Mallat, Multiresolution approximations and wavelet orthonormal bases of $L^2(\mathbb{R})$,*Trans. Amer. Math. Soc*.**315**: 69-87, 1989.

[2] P. K. Singh, B. Rashmi, Analysis of Water Parameters Using Daubechies Wavelet, American Journal of Mathematics and Statistics, **2(3)**: 57-63, 2012.

[3] J. K. Pathak, Evaluation of limnological characteristics and its trophic status of river Ramganga of western Uttar Pradesh". FTR submitted to DST, Government of India, 2008.

[4] S. Kumar, A. Kumar, R. Kumar, J. K. Pathak, Mohd. Alam, Spectral Analysis of

Biochemical Oxygen Demand in River water: An Analytical Approach to Discrete Wavelet Transform, American Journal of Mathematics and Statistics, **4(2)**: 107-112, 2014.

[5] M. Alam, J. K. Pathak, Running water environment: A case of Ramganga basin, Lambert Academic Publications, Scholars Press, Germany, 2013.

[6] I. Daubechies, Ten lectures on wavelets, *CBS-NSF, Regional Conference in Applied Mathematics,* SIAM Philadelphia **61**: 278 – 285, 1994.

[7] Quin. S. and D. Chen, *joint Time–frequency Analysis*-Methods and Applications, LongmanCheshire, Melbourne, Australia, 1992.

[8] J. P. Antoine, Wavelet analysis: A new tool in Physics, *Wavelets in Physics,* Van Der Berg, J. C.(Eds.), 9-21, 2004.

[9] Jean DuclosAlegue, Albrecht Gnauck, Signal Analysis of Water Quality Indicators.Enviro. Info 2006 (Graz). Managing Environmental Knowledge (2006), 369-376.