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Parameteric study based on synthetic realizations of EARPG(1)/UPS for simulation of extreme value statistics

Discussion by Nicholas J. Cook

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With the ability to reproduce the extreme value statistics in addition to the main body of the probability density function, the auto-correlation and the power spectral density function, it seems to me that the field of simulating wind engineering time-series data has finally come of age. So far, the application of this technology has been more or less confined to prediction of structural response, as exemplified by Choi & Noh's paper (1999) in the same issue of Wind & Structures. There is another important area for application, not yet addressed, which is the parameterisation of the pressure and load time-series measured on buildings at full and modelscale.

Parameterisation of the pressures and loads measured on buildings is a useful technique for understanding their complex behaviour and in identifying the controlling parameters. While there have been attempts to parameterise the distribution of peak pressures on building envelopes, using "proper orthogonal decomposition" techniques (Bienkiewicz, Ham and Sun 1993, Bienkiewicz *et al*. 1995, Kikuchi *et al*. 1997, Jeong and Bienkiewicz 1997) or vortex representations (Marwood and Wood 1997, Williams and Baker 1997), to my knowledge there have been no corresponding attempts to parameterise the time series. It seems most likely that the technique described in this paper will prove most useful in this respect. For example, how do the key parameters b and d, which control the shape of the PDF and the extreme-value statistics, vary from windward to leeward faces and with the pitch angle of roofs?

I suggest that this technique should be developed for the parameterisation of wind engineering time series in parallel with the current application of prediction: i.e., for analysis as well as for synthesis

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Closure by Seung H. Seong

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Thank you for your interest on the paper (Seong 1999). The technique under discussion is evidently a promising method, I think, for the analysis and synthesis studies that you suggested in the discussion. First, I should correct one thing about capability of the current technique in your discussion and will discuss on your suggestions. The technique can simulate one more property in addition to the main body of the mean and rms values and the auto-correlation function (equivalently, the power spectrum) of target sample data. The one more property can be one of non-Gaussian statistics such as skewness of parent time series data or one of the extreme value statistics. I used non-Gaussian statistics and extreme value statistics in the paper as a target property.

It is the phase part in the Fourier representation of time series that makes it possible to simulate the additional one while preserving the main body of statistics and spectrum. Because the amplitude and phase parts of the Fourier transform play a separate role in producing fluctuating characteristics of a signal. The main body of statistics and spectrum are determined by the amplitude part while the additional property is mostly dependent on the phase part. In fact, the phase is the only way to modify fluctuating features in synthetic signal under the restriction of the amplitude part.

This is a key element in the simulation methodology. The second element is the generation of non-Gaussian peak through the phase using the peak generation model and uniform phase shift process which is represented by EARPG(1)/UPS. Through the phase, the associated parameters in the model control time domain fluctuating features such as intensity and frequency of peaks. The parameter value changes result in probability density function(PDF) modifications and in turn influence extreme value statistics since the tail behavior of the PDF is directly related to extreme value distribution. The PDF simulation can not be separated from the extreme value distribution simulation. Therefore, the current technique is not able to simulate the extreme value statistics independently in addition to the overall shape of PDF of the parent population.

For the parameterization study, we should be careful to put the technique in the same line of existing analytical tools such as the proper orthogonal decomposition (POD) method. To my knowledge, the POD method, based on linear correlation functions, has a complete theory and many examples quite successful in application such as complex turbulent flow fields (Holmes, Lumley and Berkooz 1996) and data compression even though it is not very satisfactory yet, I think, in wind engineering applications, for example, in explaining the physics of the decomposed modes for the peak pressure field of building envelop (Bienkiewicz, Tamura, Ham and Ueda 1995).

The whole process of the technique under discussion cannot be viewed as a simulation of random process in one unit as seen in ordinary random processes and their simulations since the process has the form in which the EARPG(1) and the UPS are combined through the Fourier phase in the Fourier representation and the probablistic structure of the phase is still uncovered in relation to the time domain signal characteristics. In the current form of simulation method using the finite Fourier amplitude from specified power spectrum or target sample data, it is difficult to relate the phase to the various fluctuating features seen in non-Gaussian signals both in parametric and nonparametric methods. The nonparametric is in the sense that the method does not fit a parametric model to the data but uses higher-order spectum.

Even under the lack of complete mathematical description as a random process, as far as time series generation is concerned, the method provides most effective tools in that it has a great flexability in producing various peak character without changing the specified rms value and power spectrum.The technique has already shown its excellent performance in simulating non-Gaussian time series data such as wind pressure with large amplitude peaks and extreme value statistics (Seong 1999, Seong and Peterka 1997, 1998).

In order for the current technique to be used for the parameterization study you suggested, several validation studies should be preceded including extensive investigation of the effect of parameters, for example, phase shifting (Seong 1999) ; quantitative estimation of a range of parameter values for practical use; dependency of pseudo-random number generator.

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