

Simulation of daily precipitation time series using a new stochastic model

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Geoscientific fields such as clouds, spatial elevation data, temporal or spatial rainfall fields, and earthquake-slip fields are often modeled using fractals or multifractals. We first sought to apply fractional Brownian motion (fBm) or fractional Levy motion (fLm), which are simple fractal models, to simulate and generate time series of daily precipitation (R) at 51 stations in Japan. [1] We conducted spectrum analysis of the anomalies of R ($R_{\text{delta}}=R-R_{\text{ave}}$; where R_{ave} is the normal value of each day). However, we found that the fBm/fLm cannot be applied to the data because the relation between angular frequency ω and power $P(\omega)$ is not log-log linear, which is a necessary condition of a fractal. Therefore, we defined a new model, e-model, which describes the mutual relation between ω and $P(\omega)$. In the e-model, $P(\omega)$ is described as $A \exp(-B \omega)$, where A and B are approximation coefficients. [2] One generating fBm and fLm method is the filtering of white noise. If the white noise is Gaussian, then the model is fBm. However, if the white noise is Levy, then the model is fLm. Our model is not a fractal model such as fBm and fLm. However, the algorithm is similar to those. First, we generate white noise and filter the noise. Results show that, as for white noise for our model, the Levy noise is more appropriate than the Gaussian noise. [3] We simulate a time series of daily precipitation (R') using the e-model and Levy random number. The power spectrum of anomalies of R' (R'_{delta}), which were generated by us showed a similar relation to those of the e-model, which indicated that the daily precipitation time series can be calculated using the e-model and Levy random number. [4] We assume the negative values of R' as zero (no-precipitation) (hereinafter, these time series are R''). We conducted spectrum analysis of R'' . Results show that the power spectrum of R''_{delta} resembles those of R_{delta} . To conclude, we presented the possibility of generating the time series of daily precipitation using e-model and Levy random number, which is a method resembling the filtering method for fBm/fLm.

Keywords: stochastic model, Levy random number, e-model, daily precipitation time series, simulation, filtering