Progress Report on Earthquake Project

June 25, 2003

1 The choice of the velocity cutoff

The value of the velocity cutoff v_0 is one of the conditions to judge if a moving block is stuck or not. For a given time step, a smaller velocity cutoff allows a moving block to slip longer. We need to study the effect of the choice of v_0 on the physical quantities of interest. For simplicity, I chose a small system ($N = 100$) with the usual parameters ($\ell = 10$, $\alpha = 2.5$, and $\nu = 0.001$). From the magnitude distribution shown in Fig. 1 and the cluster size distribution shown in Fig. 2, we see that the cluster size distribution, n_s for $R = 1$ is much less sensitive to the choice of the velocity cutoff than the magnitude distribution, m_s, although both change little in the range $(0.0025 \leq v_0 \leq 0.0001)$. For $R = 10$, we see from Figs. 3 and 4 that they are more sensitive to v_0 than $R = 1$. Because of the similarity of the curves with $v_0 = 0.0005$ and 0.001, we can say that v_0 from 0.0005 to 0.001 is suitable.

Table 1 shown the running time at Athlon MP 2200+ CPU to get 10^7 events for the above systems. Because a smaller values of v_0 requires a longer time, I chose $v_0 = 0.001$ for both $R = 1$ and $R = 10$. However, I have not determined the effect of the cutoff for $R = 20$ and 30.

Table 1: Running time (hours) to obtain 10^7 events for different values of v_0 and R on Athlon MP 2200+.

N	R	$v_0 = 0.0025$	$v_0 = 0.001$	$v_0 = 0.0005$	$v_0 = 0.0001$
100	1	14.52	14.45	14.09	21.20
100	10	248.67	256.70	255.31	376.47

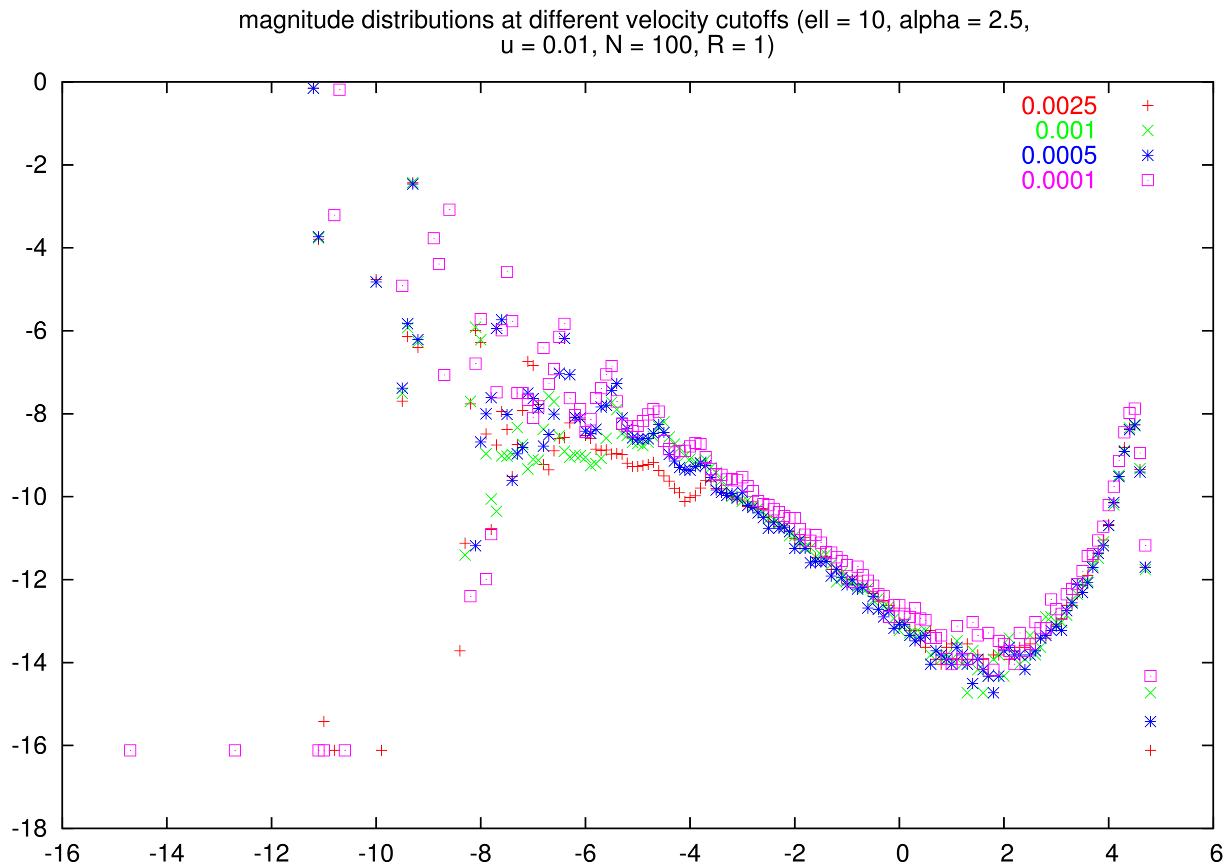

Figure 1: Log-linear plot of the magnitude distributions for different v_0 with the parameters $N = 100$, $\nu = 0.01$, $\alpha = 2.5$, $\ell = 10$, and $R = 1$. In the following I choose $v_0 = 0.001$.

2 The cluster size distribution

Two moving blocks are in the same cluster if they are within the interaction range. (I used a similar difference last year; the main difference is that I calculate the frictional force differently if the block is stuck.) The number of blocks in a cluster is the size of that cluster, and no lifetime of the cluster is involved. I calculated the cluster size distribution for the same systems with the velocity cutoff $v_0 = 0.001$ for different N and interaction range R.

Fig. 5 shows the cluster size distributions for $R = 1$, 10, 20, 30, but with the same system size $N = 1000$. For $R = 1$, the scaling regions are not so well-defined. I fitted them nevertheless and obtained the slope 2.52 for

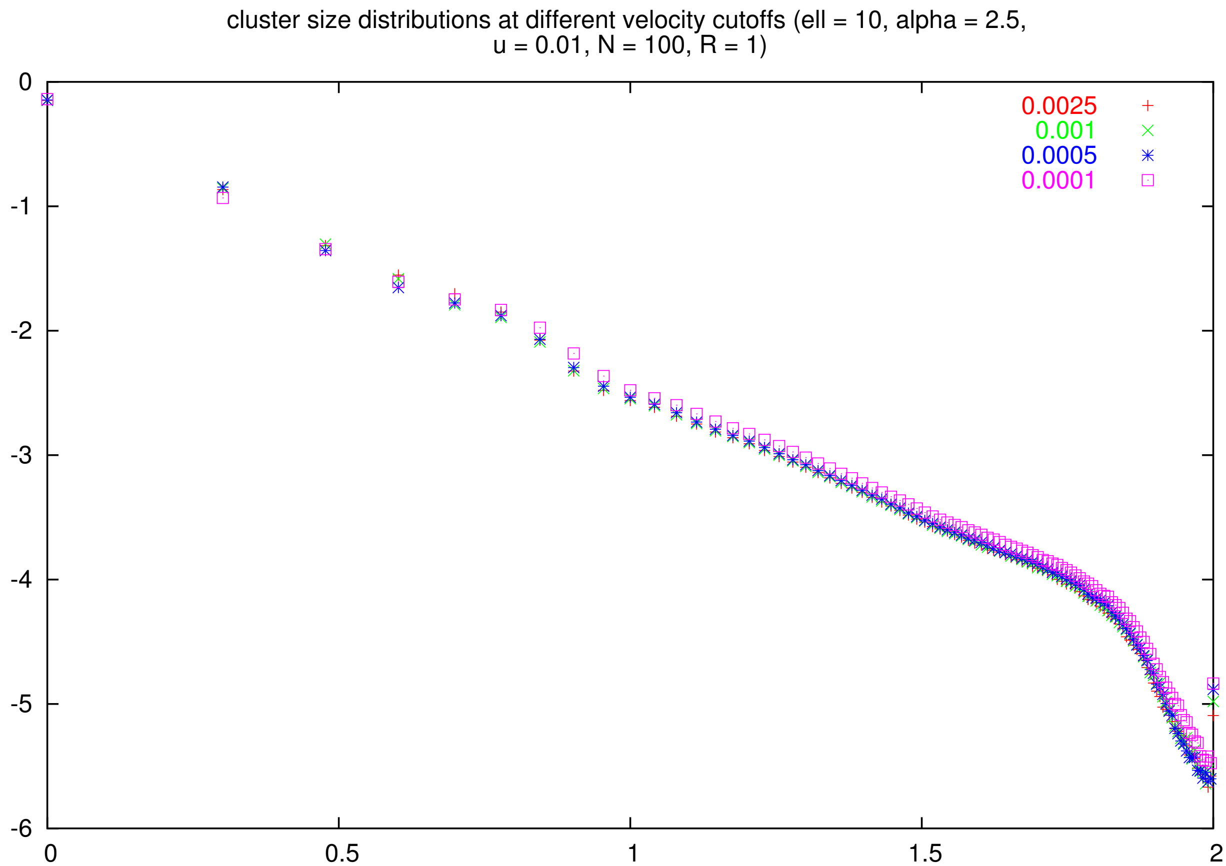

Figure 2: Log-log plot of the cluster size distributions for different v_0 with the same parameters as Fig. 1.

$0.4 \leq \log s \leq 0.7$ and 2.66 for $1.0 \leq \log s \leq 1.75$. However, two or three scaling regions appear with an increase of R. Figs. 6, 7, and 8 show the cluster size distribution and its fits $R = 10$, 20, and 30 respectively. The range and exponents are listed in Table 2.

3 Summary

1. The cluster size distribution is less sensitive to the choice of the velocity cutoff. v_0 from 0.001 to 0.0005 is suitable for the time step 0.005 for $R = 1$ and $R = 10$.

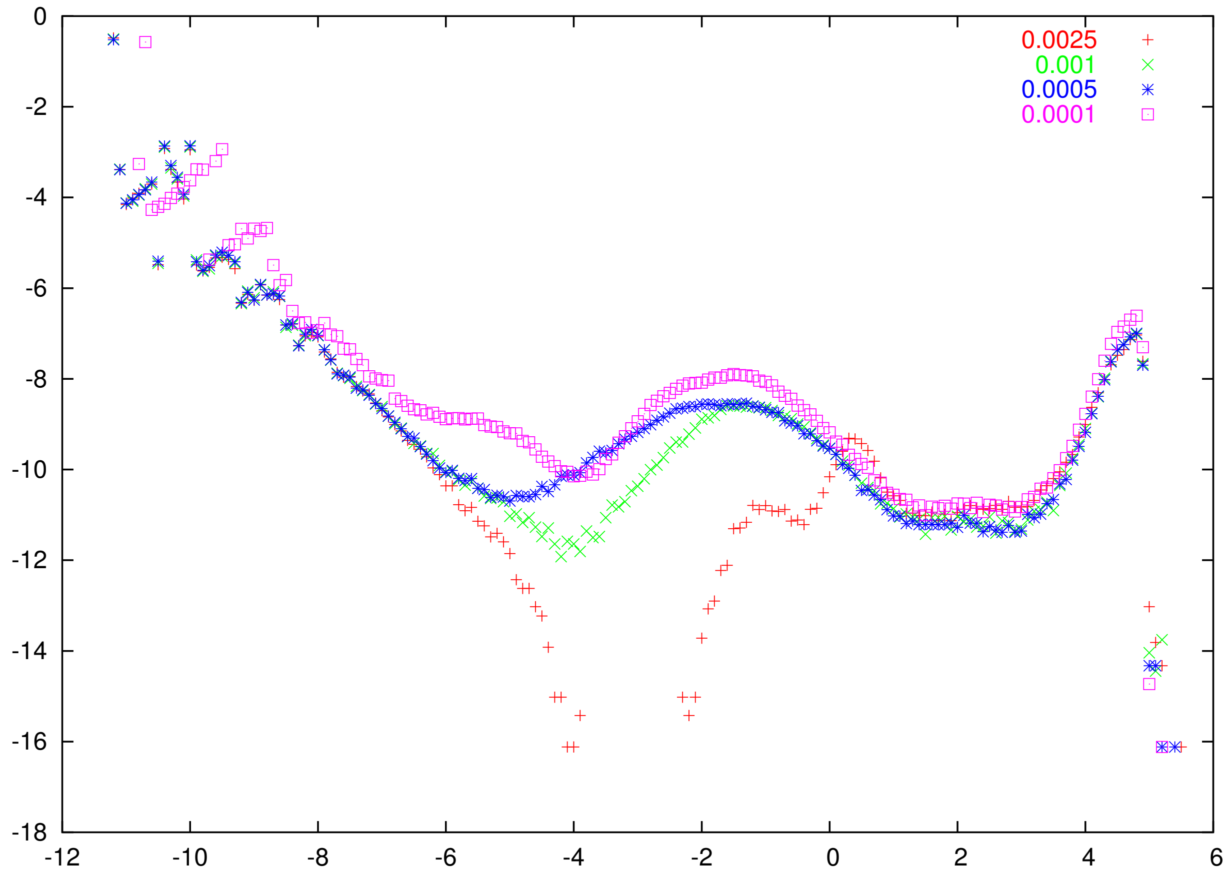

Figure 3: Log-linear plots of the magnitude distributions for different v_0 with the same parameters as Fig. 1 except $R = 10$.

2. Three scaling regions appear with the increase of R. Their slopes are shown in Table 2.

4 Things to do

1. Obtain the distributions for larger systems and longer interaction ranges;
2. Look for smarter algorithm to find clusters and optimize the program;
3. Obtain distributions in the limit of zero loading rate;
4. Limit the blocks to move forward only;

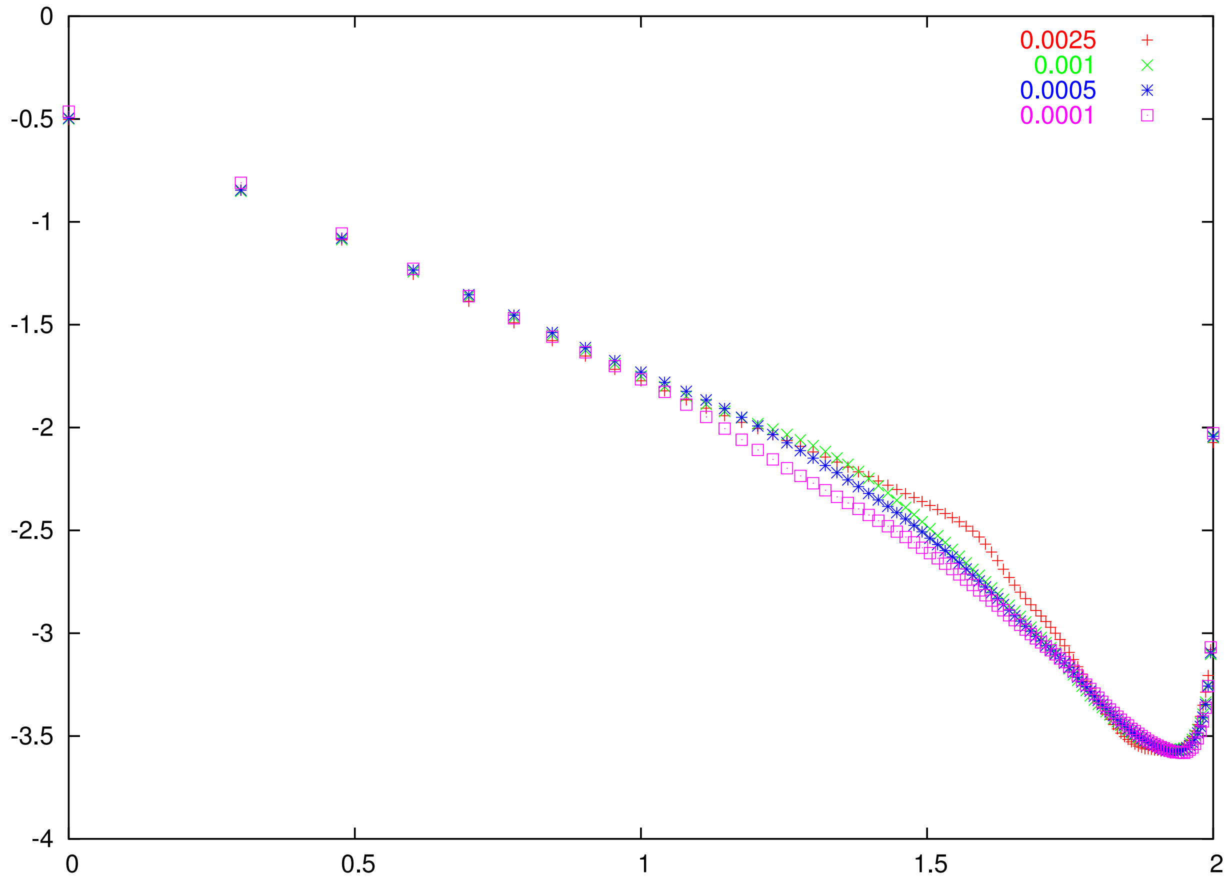

Figure 4: Log-log plots of the cluster size distributions for different v_0 with the same parameters as Fig. 3.

5. Add random noise;

6. Change the stiffness or use a variable spring constant;

7. Simulate the two-dimensional model.

Table 2: Fitted scaling regions and exponents from cluster size distributions (The ranges are estimated by eyes. Usually the slopes are fitted by shorter ranges shown in corresponding figs.)

N	R	Scaling Range 1	Scaling Range 2	Scaling Range 3
1000	1	$0.4 \to 0.7$, 2.52	$1.0 \to 1.75$, 2.66	none?
1000	10	$0.0 \to 1.0$, 1.46	$1.0 \to 1.65$, 1.92	$1.65 \to 2.5$, 2.34
1000	20	$0.0 \to 1.0$, 1.06	$1.0 \to 1.85$, 1.69	$1.85 \to 2.8$, 2.37
1000	30	$0.0 \to 1.0$, 0.99	$1.0 \to 2.00$, 1.58	$2.00 \to 3.0$, 2.39

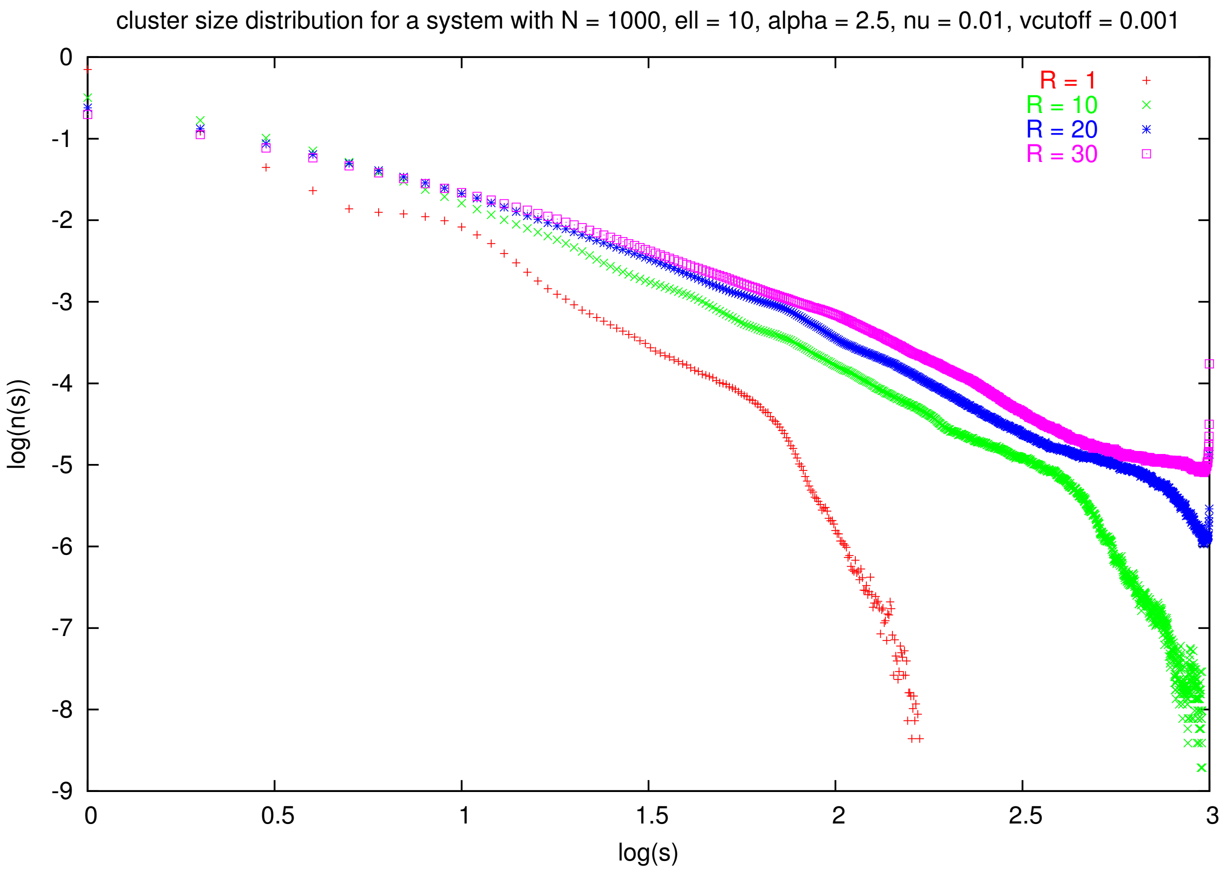

Figure 5: Log-log plot of the cluster size distribution for $N = 1000$, $v_0 = 0.001$ and $R = 1$, 10, 20 and 30.

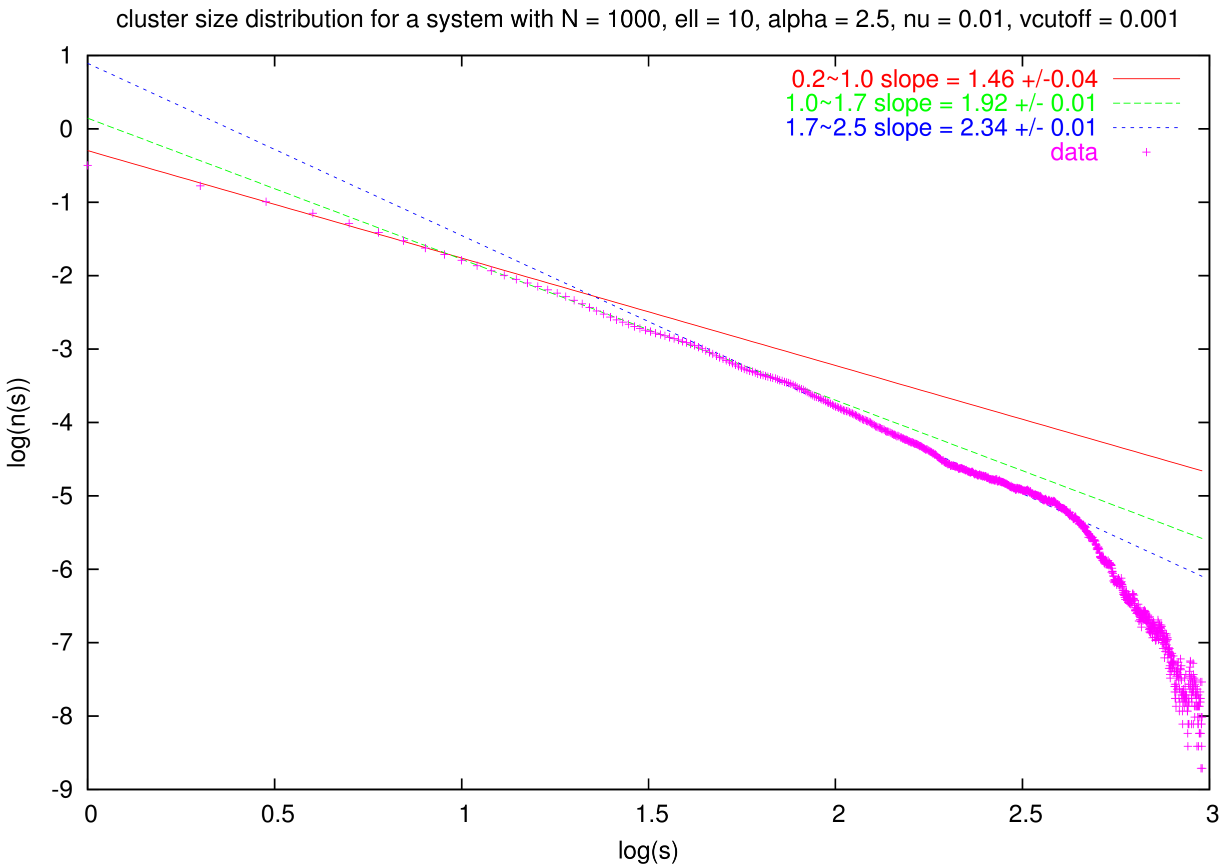

Figure 6: The same as Fig. 5 except $R = 10$. Three scaling ranges can be fitted: $0.2 \leq \log s \leq 1.0$ with slope 1.46; $1.0 \leq \log s \leq 1.7$ with slope 1.92; $1.7 \leq \log s \leq 2.5$ with slope 2.34.

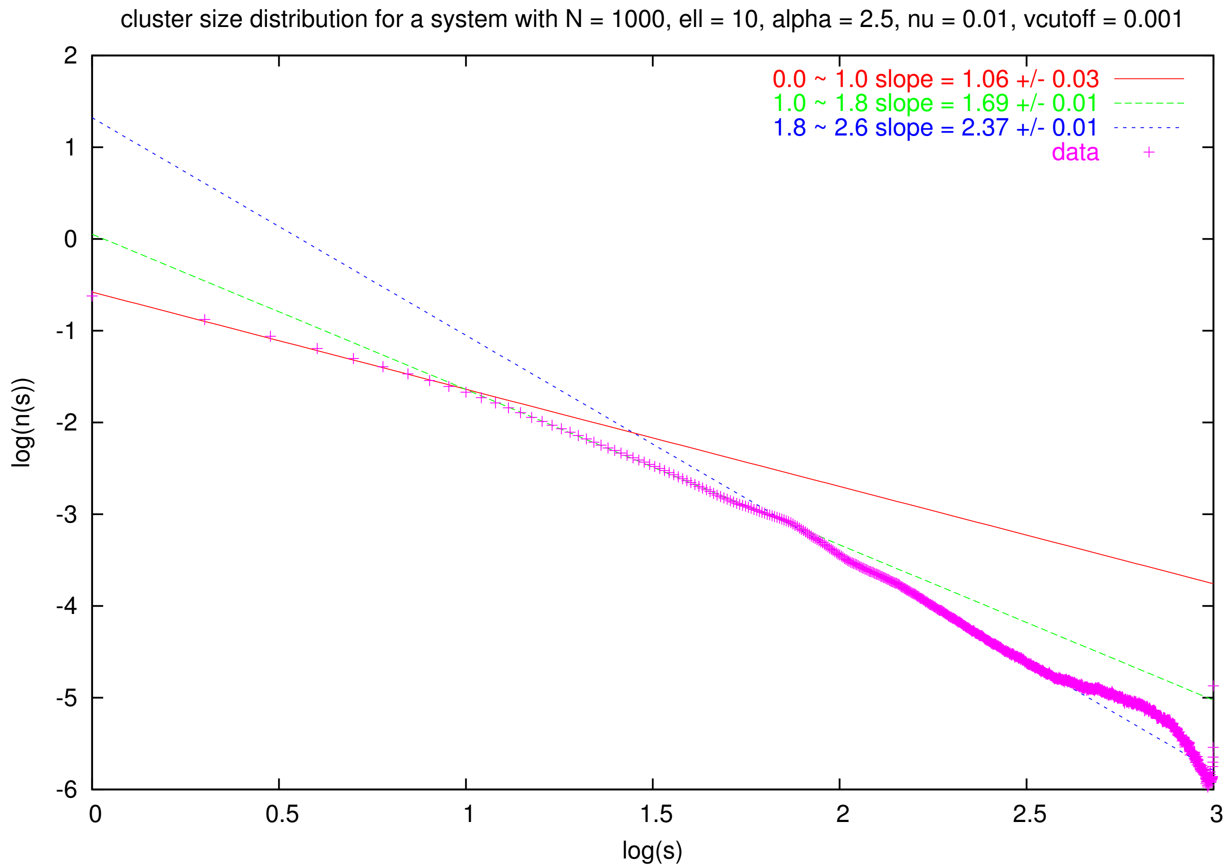

Figure 7: The same as Fig. 5 except $R = 20$. Three scaling ranges can be fitted: $0.0 \leq \log s \leq 1.0$ with slope 1.06; $1.0 \leq \log s \leq 1.8$ with slope 1.69; $1.8 \leq \log s \leq 2.6$ with slope 2.37.

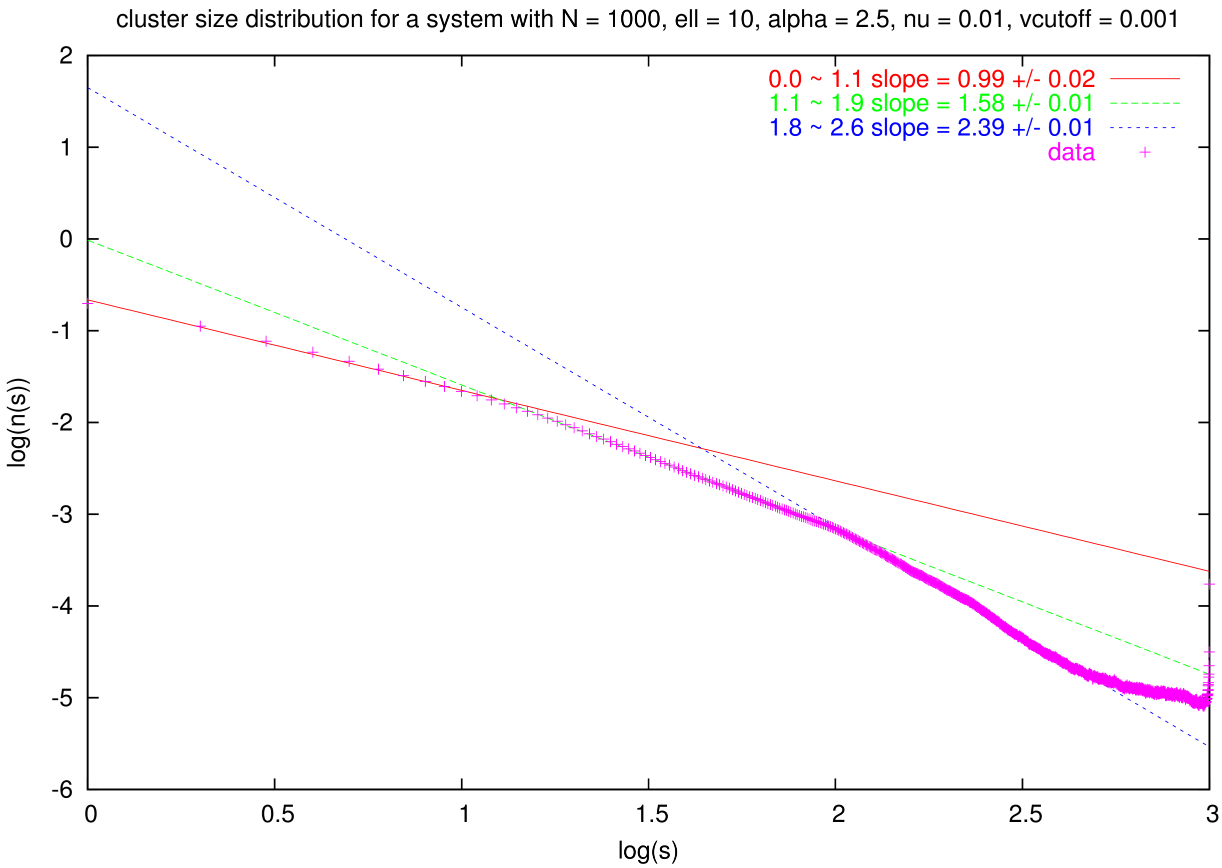

Figure 8: The same as Fig. 5 except $R = 30$. Three scaling ranges can be fitted: $0.1 \leq \log s \leq 1.1$ with slope 0.99; $1.1 \leq \log s \leq 1.9$ with slope 1.58; $1.9 \leq \log s \leq 2.7$ with slope 2.39.