In [1]:
```
include("../Sandpile.jl")
using .Sandpile
using Plots
```

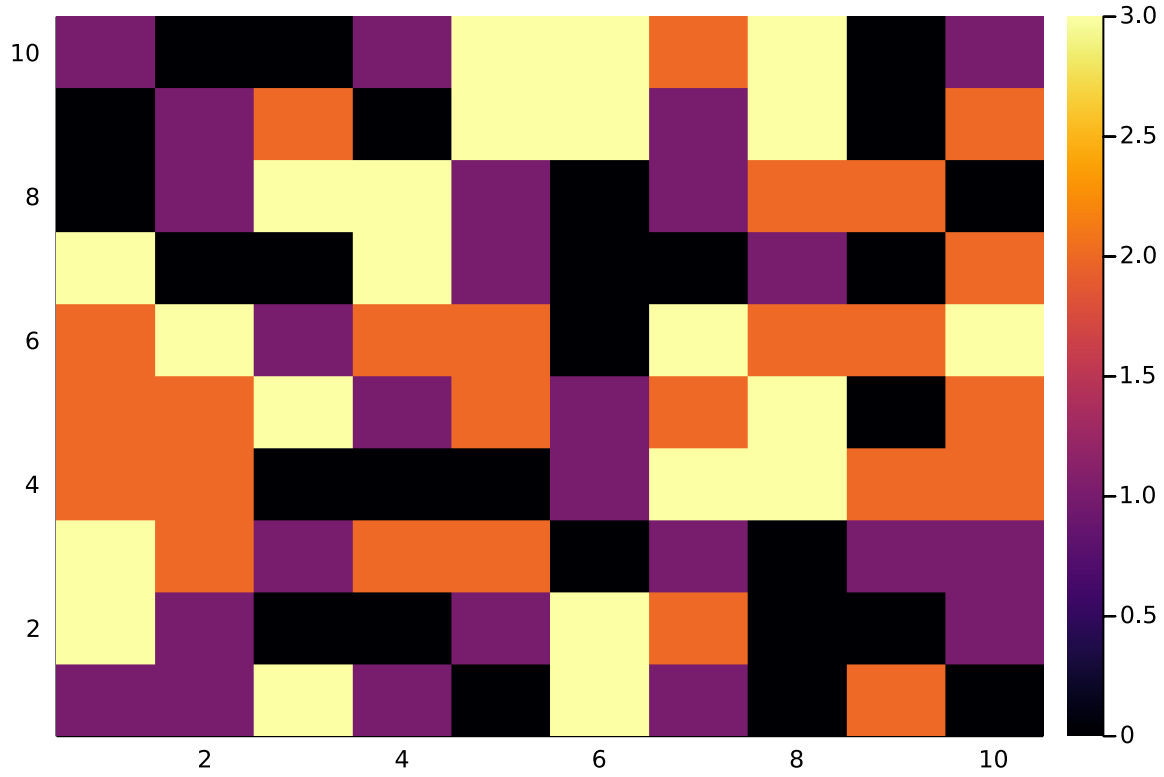
Functions for Implementing Sandpile Rules

In [2]:
```
x, y = 10, 10; # Dimensions of grid
N = 100; # Number of grains to be added
f_χ = 4; # Critical value for sandpile model
```

We can choose to have a random initial set-up

In [3]:
```
z = sandpile_init(x, y, "random");
heatmap(1:x, 1:y, z)
```

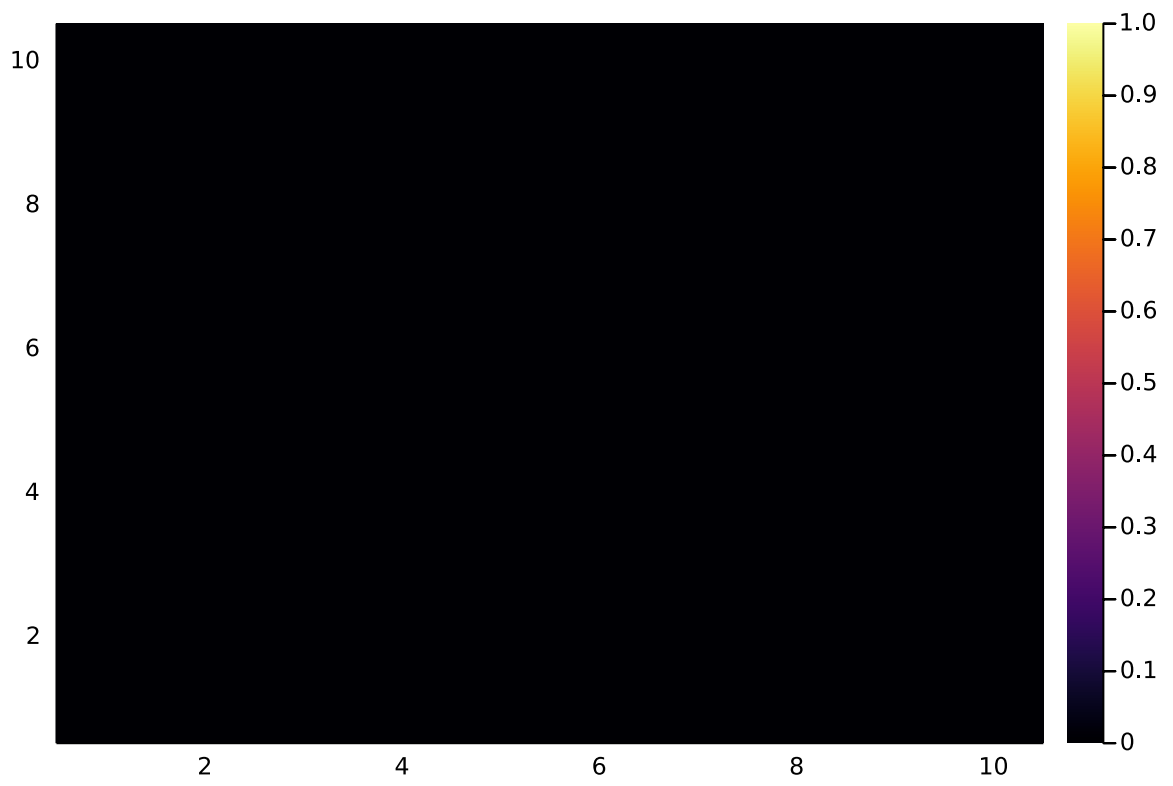
Out[3]:



Or we can choose to initialize the grid with all 0s

In [4]:
```
z = sandpile_init(x, y, "zero");
heatmap(1:x, 1:y, z)
```

Out[4]:

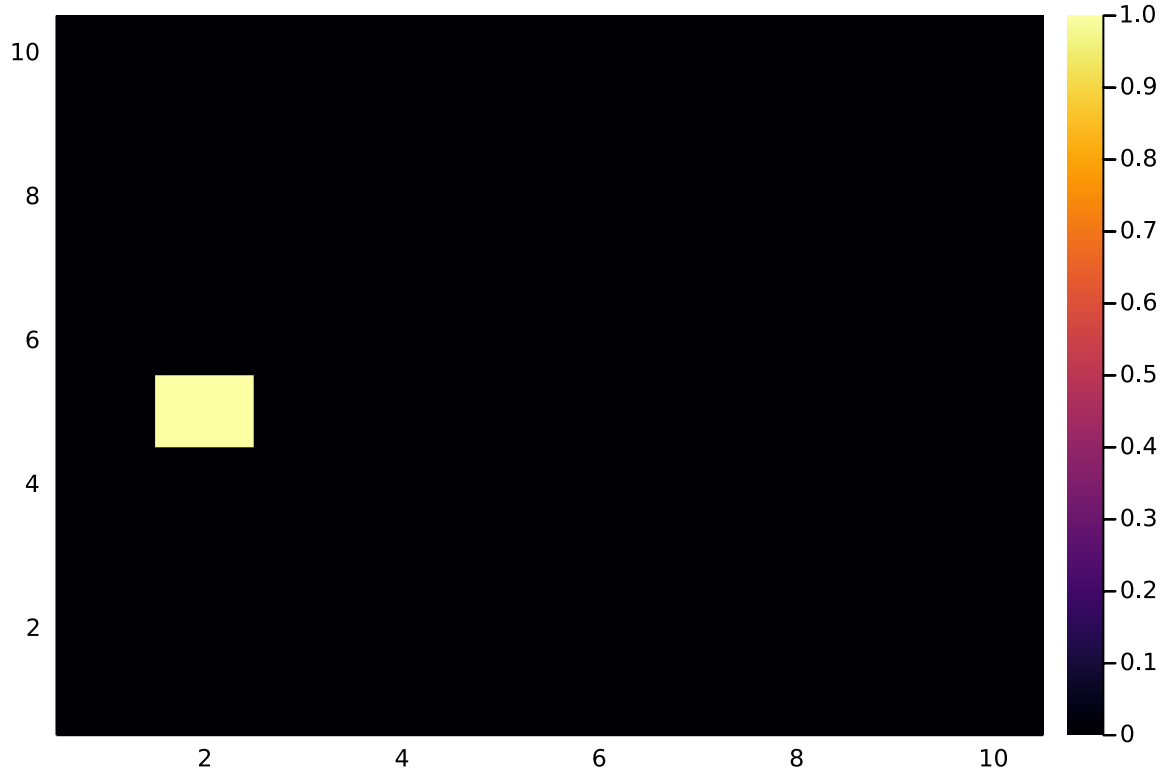


Example of a grain being added on previous grid

In [5]:

```
add_grain!(z);
heatmap(1:x, 1:y, z)
```

Out[5]:



`is_unstable()` checks if there are any points greater than the critical value

In [6]:

```
is_unstable(z)
```

Out[6]:

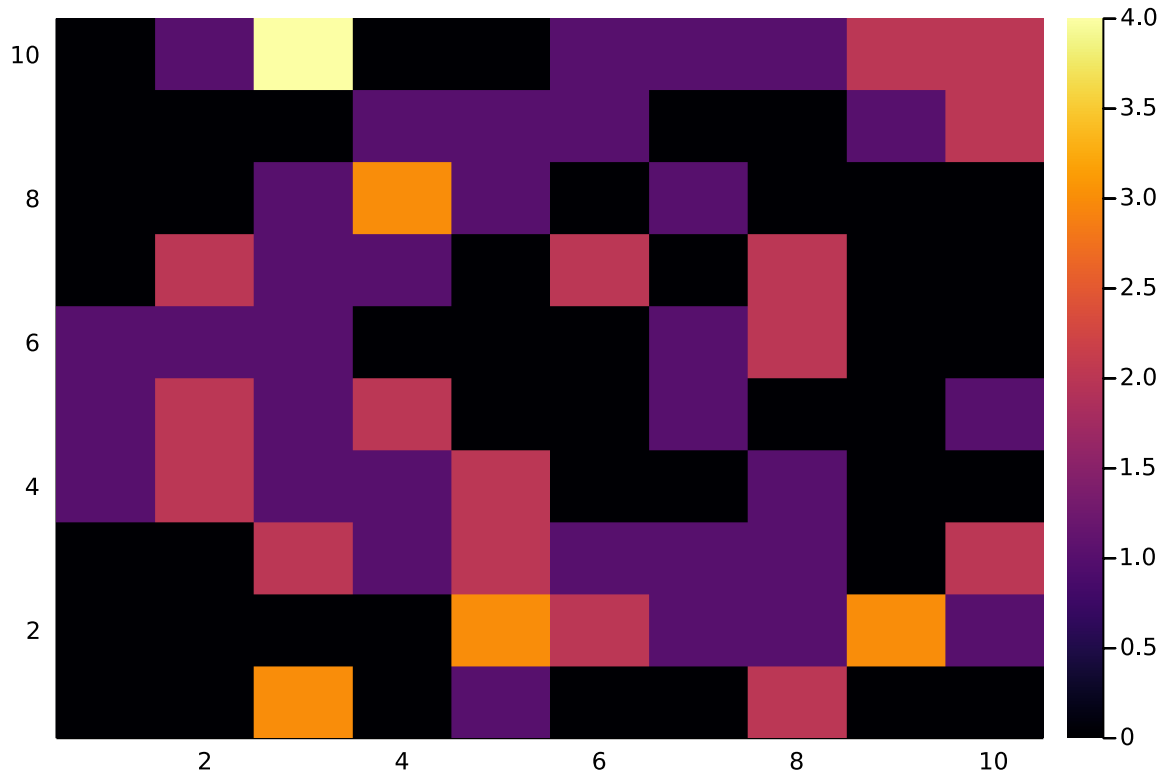
```
false
```

In [7]:
```
[add_grain!(z) for i in 1:80]
is_unstable(z)
```

Out[7]:
```
true
```

In [8]:
```
heatmap(1:x, 1:y, z)
```

Out[8]:

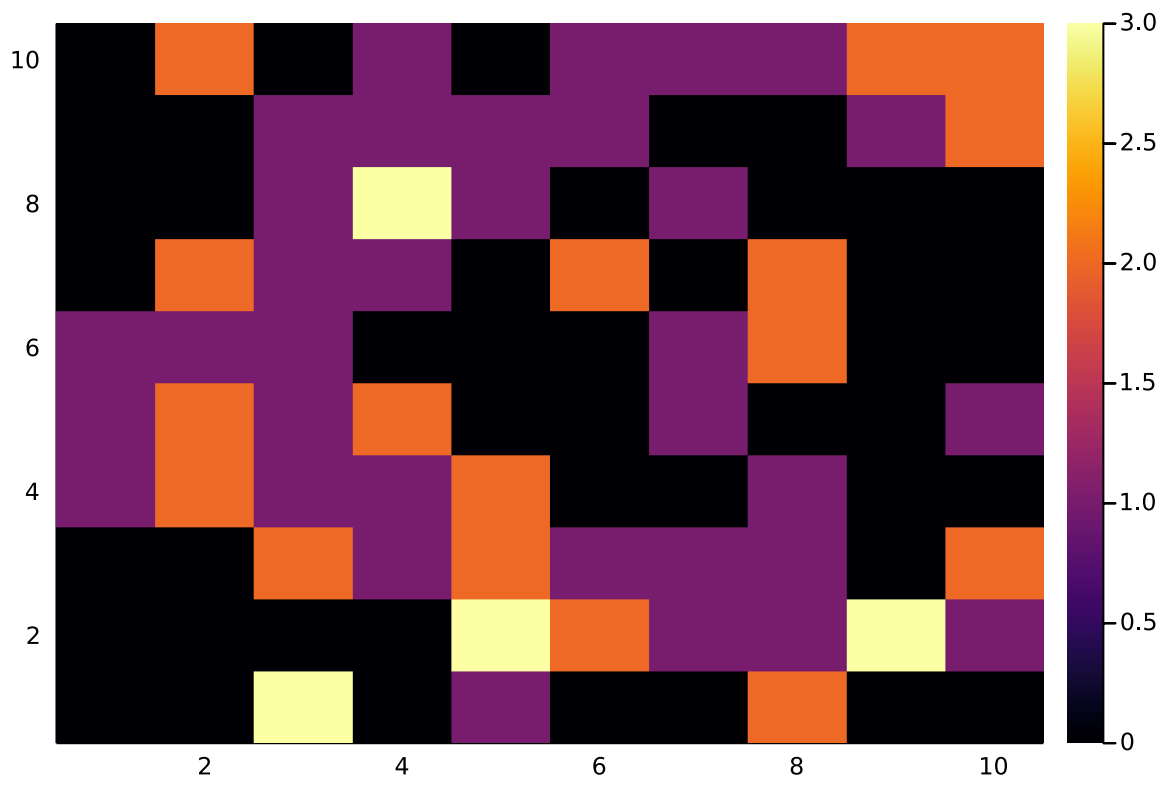


Note that after running `avalanche!()`, the highest number of grains is now below the critical value of 4.

In [9]:
```
avalanche!(z);
```

In [10]:
```
heatmap(1:x, 1:y, z)
```

Out[10]:

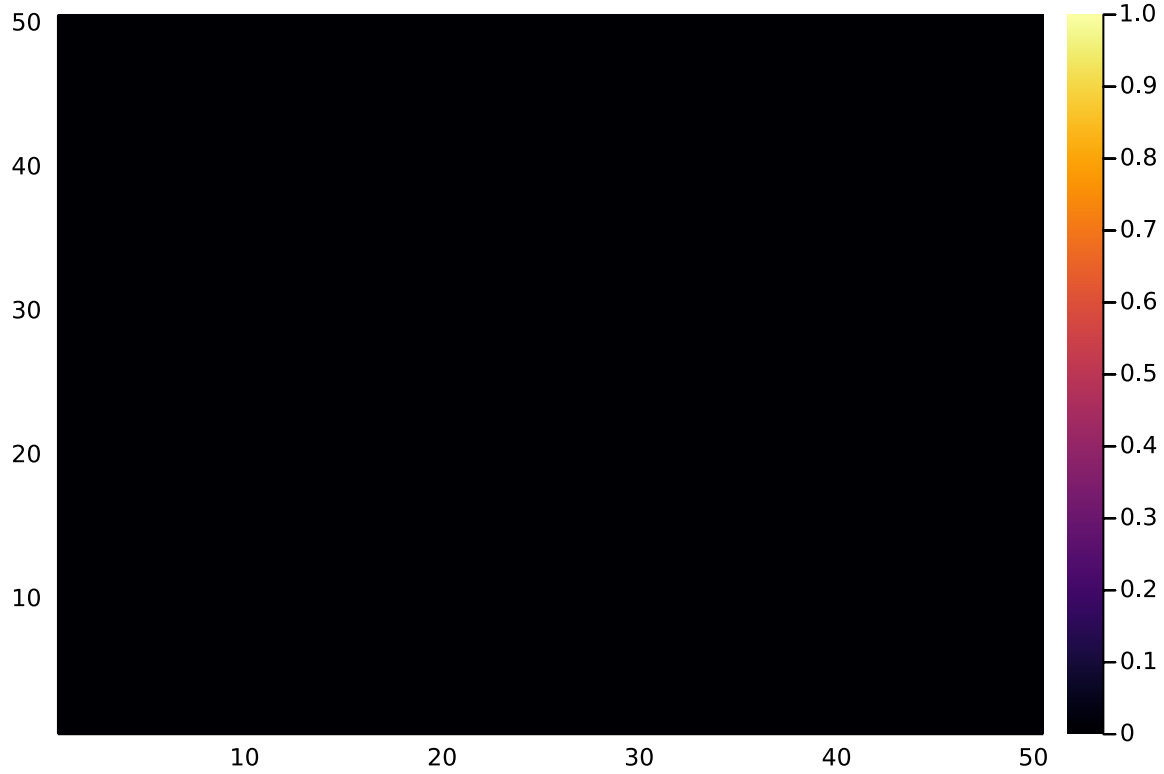


Putting it all together

In [11]:

```
x = 50
y = 50
z = sandpile_init(x, y, "zero");
heatmap(1:x, 1:y, z)
```

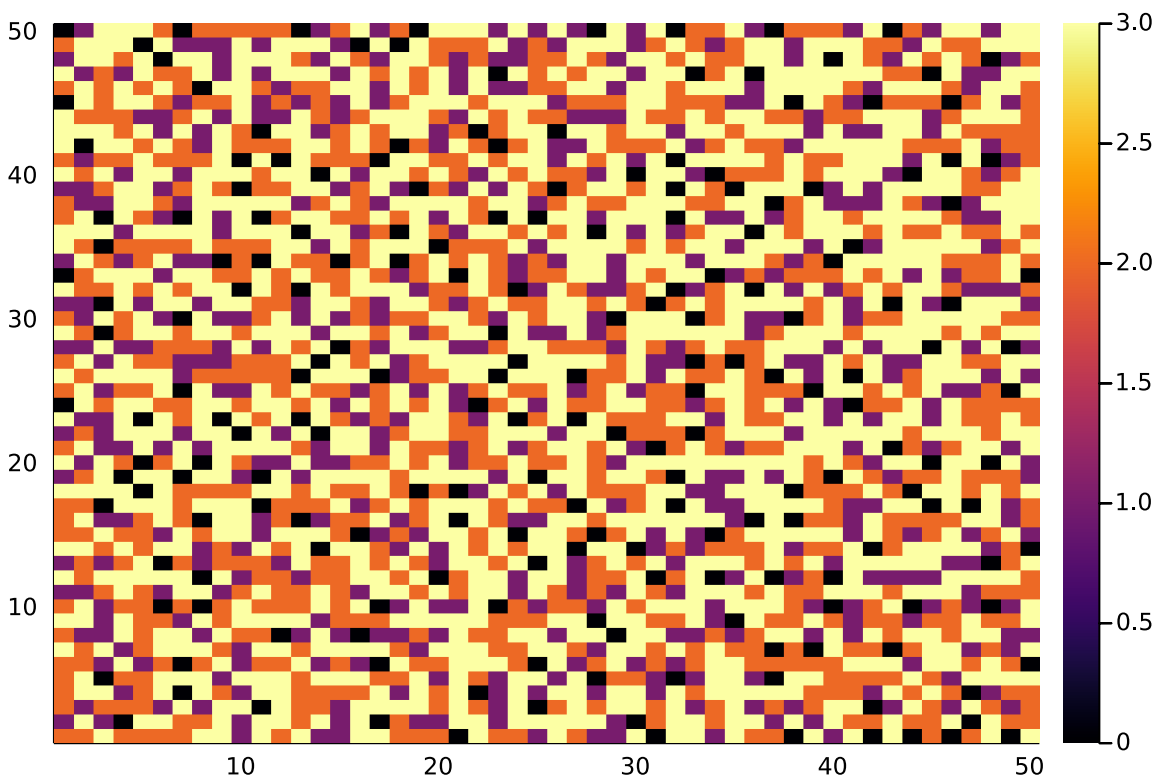
Out[11]:



In [12]:

```
s = run_sandpile!(z, 100_000);
heatmap(1:x, 1:y, z)
```

Out[12]:



Counting avalanche sizes

Note that sizes of avalanches for each grain added are returned by `run_sandpile`. If the argument `N_crit` is false, it returns a list of all avalanches that occurred ie running the previous cell returns 41926 values after adding 100_000 grains. I added an option of setting `N_crit` = true wherein it will only stop after adding 100_000 (or `N`) grains that all result in at least one avalanche; as expected using this option leads to longer running times.

In [13]:

```
s'
```

Out[13]:

```
1×41926 adjoint(::Vector{Int64}) with eltype Int64:
 1  1  1  1  1  1  1  2  1  1  1  2  1  …  8  1  4  5  1  662  33  1  10  74
```

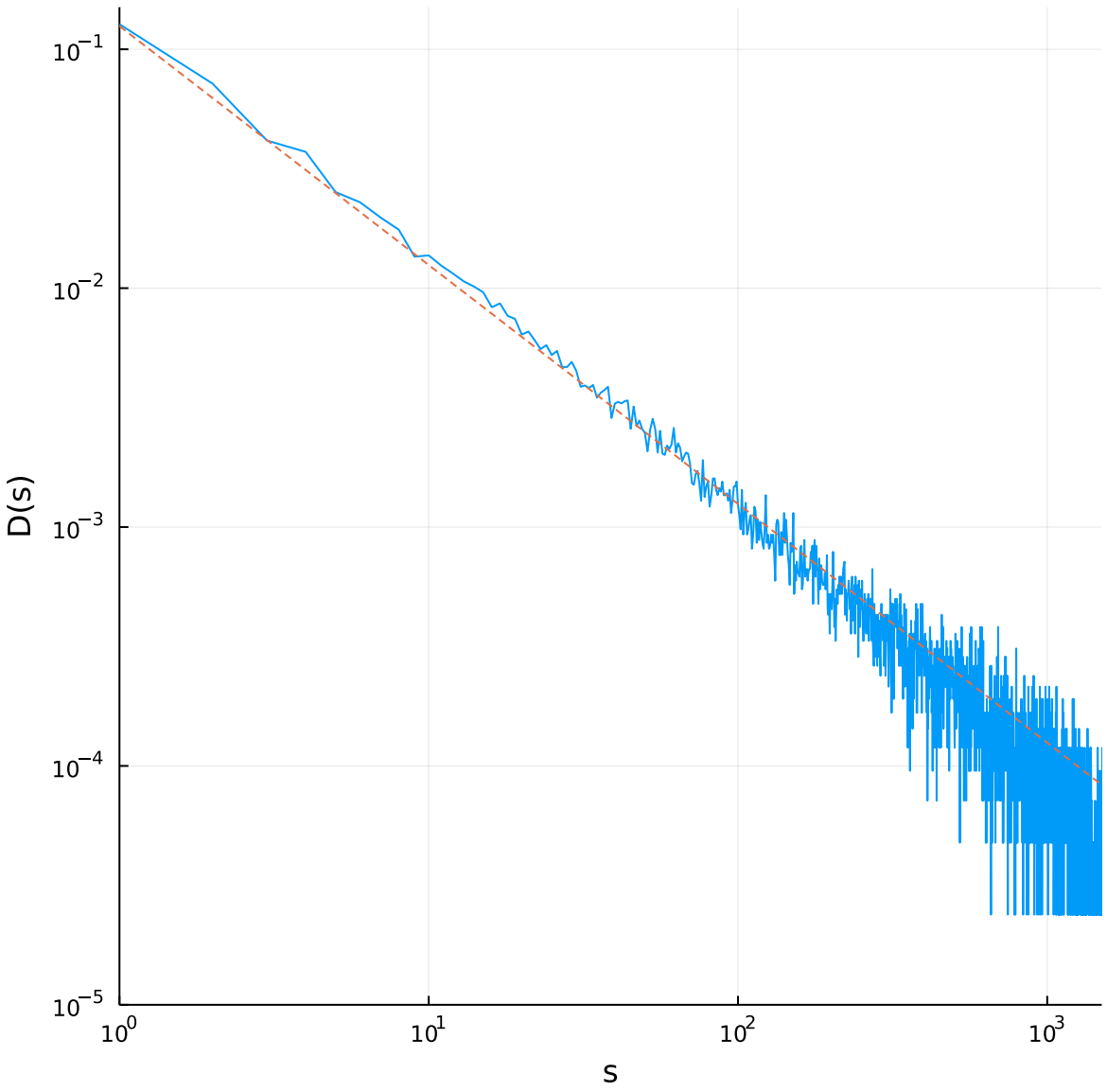
We can choose to plot distribution of the cluster sizes below

In [14]:

```
# Get counts of each slide size s
unique_s = sort(unique(reduce(vcat, s)))
counts = [count(==(element), reduce(vcat, s)) for element in unique_s]
yticks = [1e-1, 1e-2, 1e-3, 1e-4, 1e-5, 1e-6]
xticks = [1e0, 1e1, 1e2, 1e3]
plot(
    unique_s,
    counts ./ sum(counts);
    xaxis=:log,
    yaxis=:log,
    leg=false,
    yticks=yticks,
    xticks=xticks,
    size=(600, 600),
    dpi=300,
)
plot!(
    [1e0, 1e5],
    [1.25e-1, 1.25e-6];
    xaxis=:log,
    yaxis=:log,
```

```
    xlabel="s",
    ylabel="D(s)",
    xlim=(1e0, 1.5e3),
    ylim=(1e-5, 1.5e-1),
    linestyle=:dash,
    dpi=300,
)
```

Out[14]:



In [ ]: