Title: Numerical Methods Lecture

Speakers: Dustin Lang

Collection: Numerical Methods 2023/24

Date: January 23, 2024 - 10:15 AM

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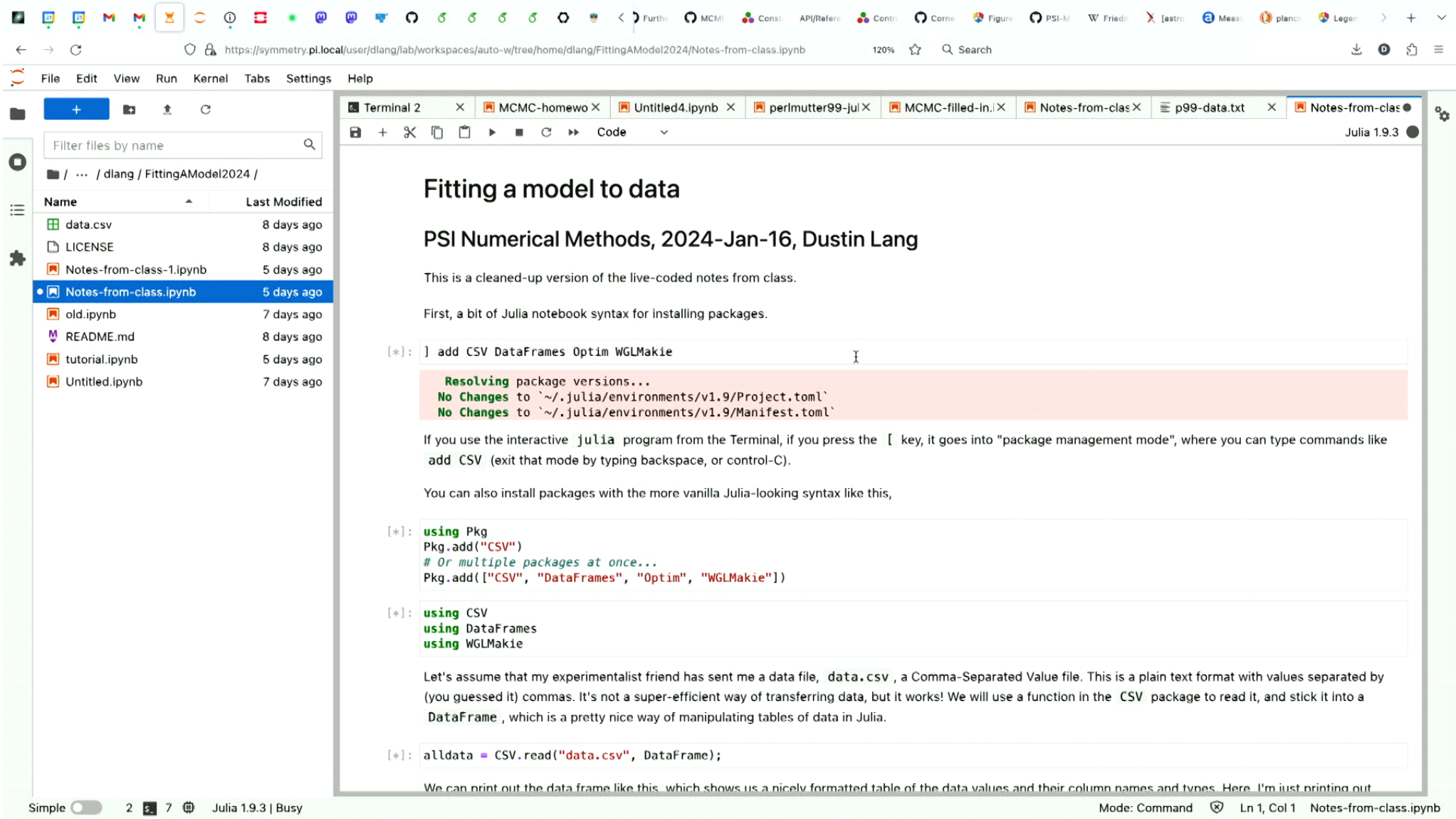
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Fitting a model to data
PSI Numerical Methods, 2024-Jan-16, Dustin Lang
This is a cleaned-up version of the live-coded notes from class.
First, a bit of Julia notebook syntax for installing packages.
] add CSV DataFrames Optim WGLMakie
Resolving package versions...
No Changes to `~/.julia/environments/v1.9/Project.toml`
No Changes to `~/.julia/environments/v1.9/Manifest.toml`
If you use the interactive julia program from the Terminal, if you press the [key, it goes into "package management mode", where you can type commands like add CSV (exit that mode by typing backspace, or control-C).
You can also install packages with the more vanilla Julia-looking syntax like this,
using Pkg
Pkg.add("CSV")
# Or multiple packages at once...
Pkg.add(["CSV", "DataFrames", "Optim", "WGLMakie"])
using CSV
using DataFrames
using WGLMakie
Let's assume that my experimentalist friend has sent me a data file, data.csv , a Comma-Separated Value file. This is a plain text format with values separated by (you guessed it) commas. It's not a super-efficient way of transferring data, but it works! We will use a function in the CSV package to read it, and stick it into a DataFrame , which is a pretty nice way of manipulating tables of data in Julia.
alldata = CSV.read("data.csv", DataFrame);
We can print out the data frame like this, which shows us a nicely formatted table of the data values and their column names and types. Here, I'm just printing out
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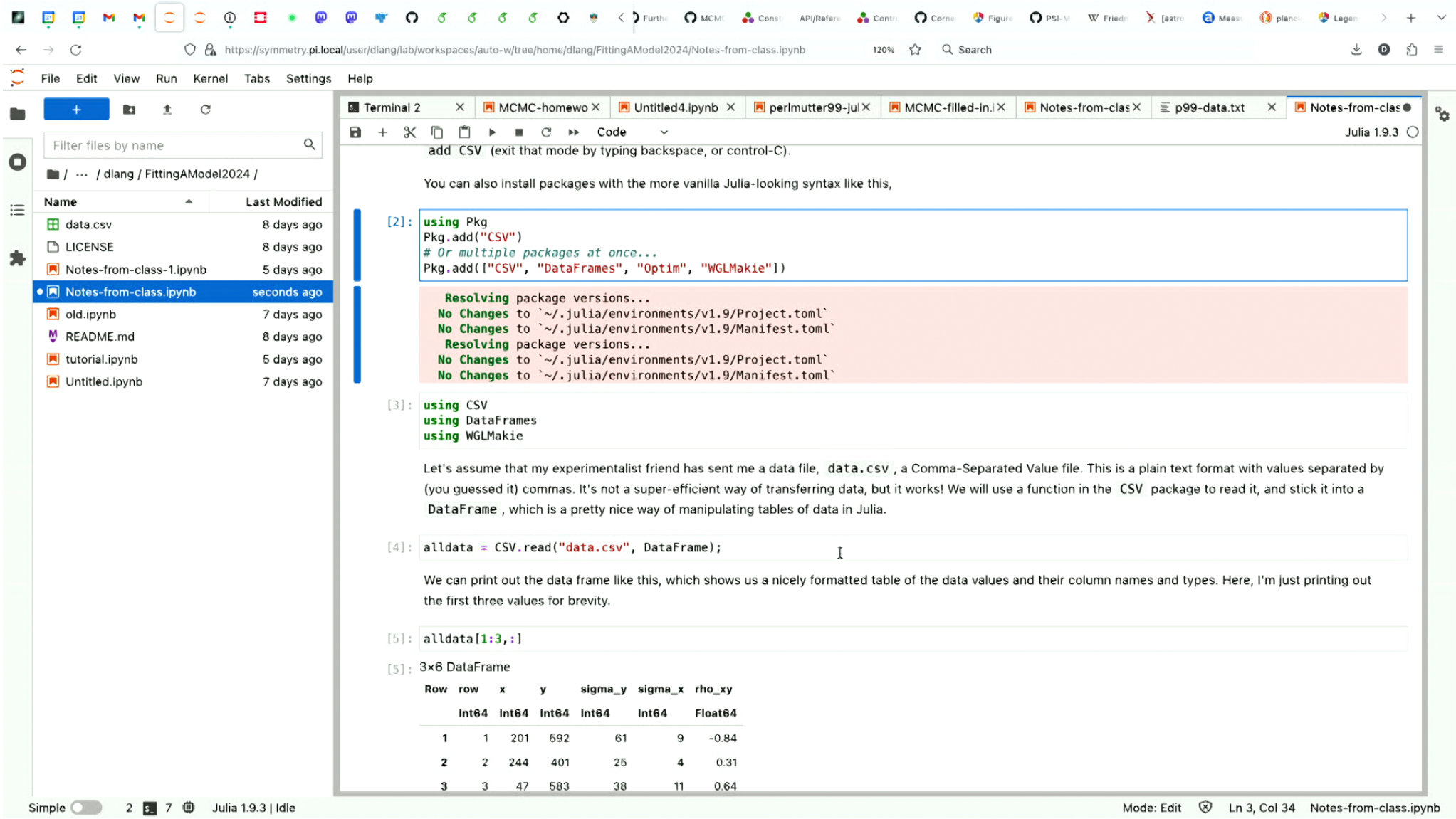
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[3]:
using CSV
using DataFrames
using WGLMakie
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[4]:
alldata = CSV.read("data.csv", DataFrame);
We can print out the data frame like this, which shows us a nicely formatted table of the data values and their column names and types. Here, I'm just printing out the first three values for brevity.
[5]:
alldata[1:3,:]
[5]: 3×6 DataFrame
Row row x y sigma_y sigma_x rho_xy
Int64 Int64 Int64 Int64 Int64 Float64
1 1 201 592 61 9 -0.84
2 2 244 401 25 4 0.31
3 3 47 583 38 11 0.64
Simple 2 7 Julia 1.9.3 | Idle
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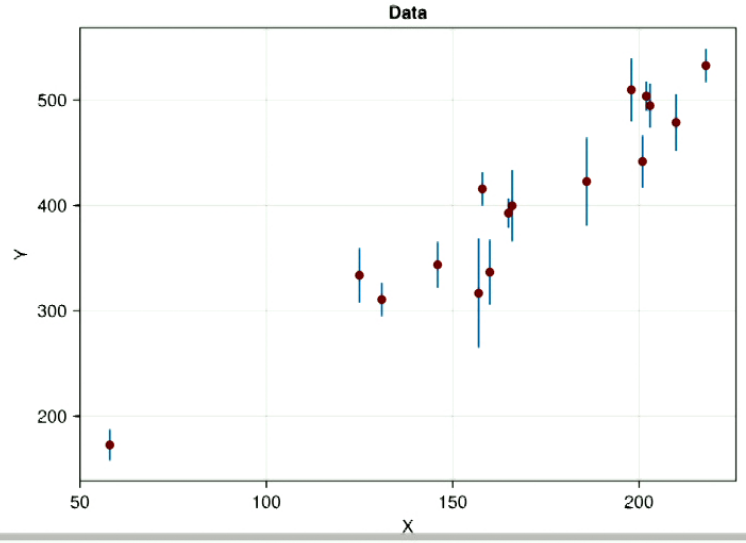
Let's have a quick look (and remind ourselves how to make plots with labelled axes and titles). The data table contains `x` and `y` values, and also `sigma_y`, that give (our experimentalist friends tell us) the Gaussian uncertainties on the measured values.

The data table actually also contains `sigma_x` values, but for now we are going to ignore those -- a pretty common thing to do in cases where one of the values is measured extremely well.

[40]:
```
f = Figure()
Axis(f[1,1], title="Data", xlabel="X", ylabel="Y")
errorbars!(data.x, data.y, data.sigma_y)
# You can plot multiple things on the same plot using these commands ending with "!".
# The "!" is a common thing in Julia that means "this function modifies the state".
scatter!(data.x, data.y, markersize=10, color=:maroon)
f
```

[40]:



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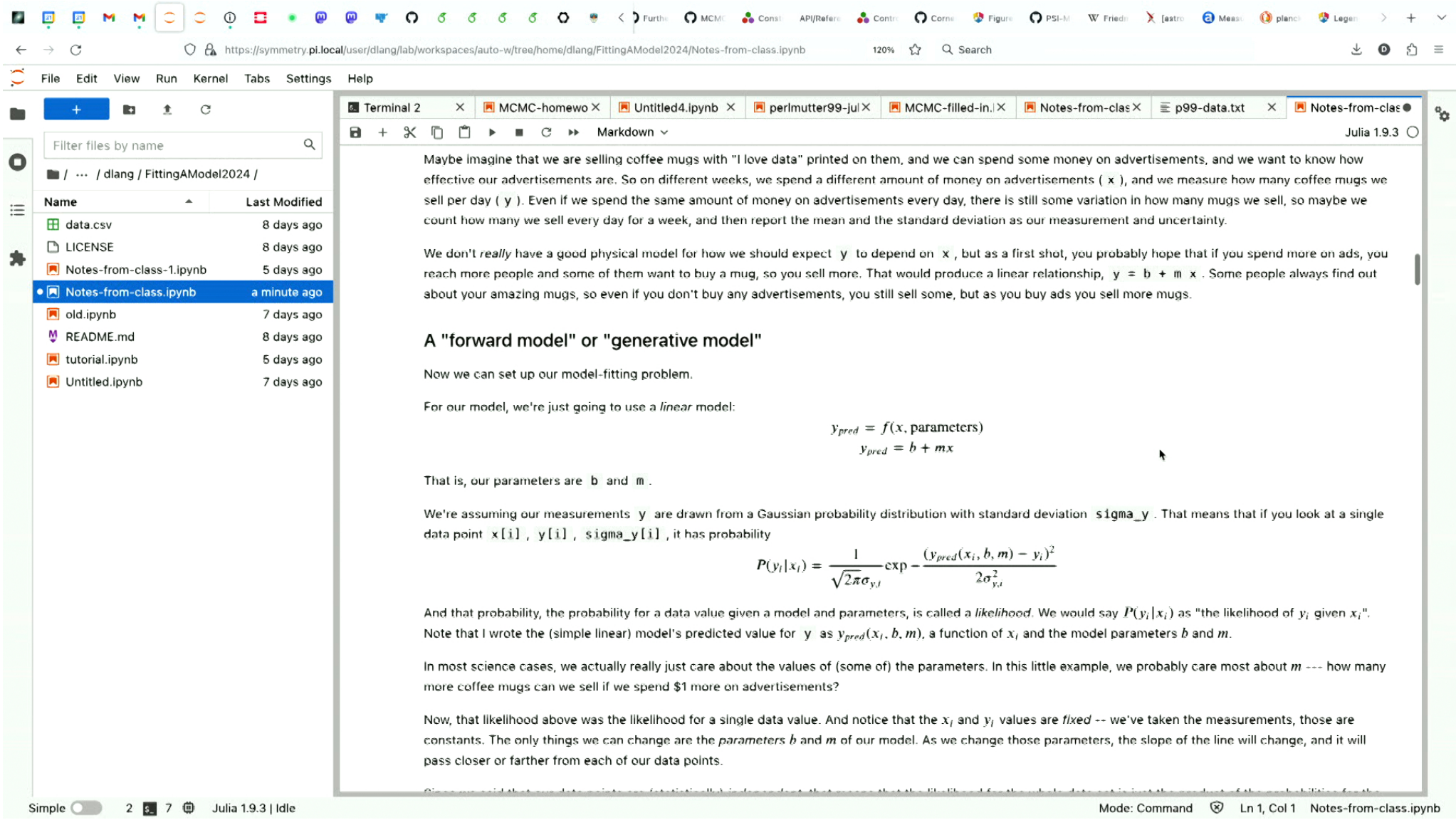
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Maybe imagine that we are selling coffee mugs with "I love data" printed on them, and we can spend some money on advertisements, and we want to know how effective our advertisements are. So on different weeks, we spend a different amount of money on advertisements (x), and we measure how many coffee mugs we sell per day (y). Even if we spend the same amount of money on advertisements every day, there is still some variation in how many mugs we sell, so maybe we count how many we sell every day for a week, and then report the mean and the standard deviation as our measurement and uncertainty.
We don't really have a good physical model for how we should expect y to depend on x , but as a first shot, you probably hope that if you spend more on ads, you reach more people and some of them want to buy a mug, so you sell more. That would produce a linear relationship, y = b + m x . Some people always find out about your amazing mugs, so even if you don't buy any advertisements, you still sell some, but as you buy ads you sell more mugs.
A "forward model" or "generative model"
Now we can set up our model-fitting problem.
For our model, we're just going to use a linear model:
$$y_{pred} = f(x, \text{parameters})$$
$$y_{pred} = b + mx$$
That is, our parameters are b and m .
We're assuming our measurements y are drawn from a Gaussian probability distribution with standard deviation sigma_y . That means that if you look at a single data point x[i] , y[i] , sigma_y[i] , it has probability
$$P(y_i|x_i) = \frac{1}{\sqrt{2\pi}\sigma_{y,i}} \exp - \frac{(y_{pred}(x_i, b, m) - y_i)^2}{2\sigma_{y,i}^2}$$
And that probability, the probability for a data value given a model and parameters, is called a likelihood. We would say $P(y_i|x_i)$ as "the likelihood of y_i given x_i". Note that I wrote the (simple linear) model's predicted value for y as $y_{pred}(x_i, b, m)$, a function of x_i and the model parameters b and m.
In most science cases, we actually really just care about the values of (some of) the parameters. In this little example, we probably care most about m --- how many more coffee mugs can we sell if we spend $1 more on advertisements?
Now, that likelihood above was the likelihood for a single data value. And notice that the x_i and y_i values are fixed -- we've taken the measurements, those are constants. The only things we can change are the parameters b and m of our model. As we change those parameters, the slope of the line will change, and it will pass closer or farther from each of our data points.
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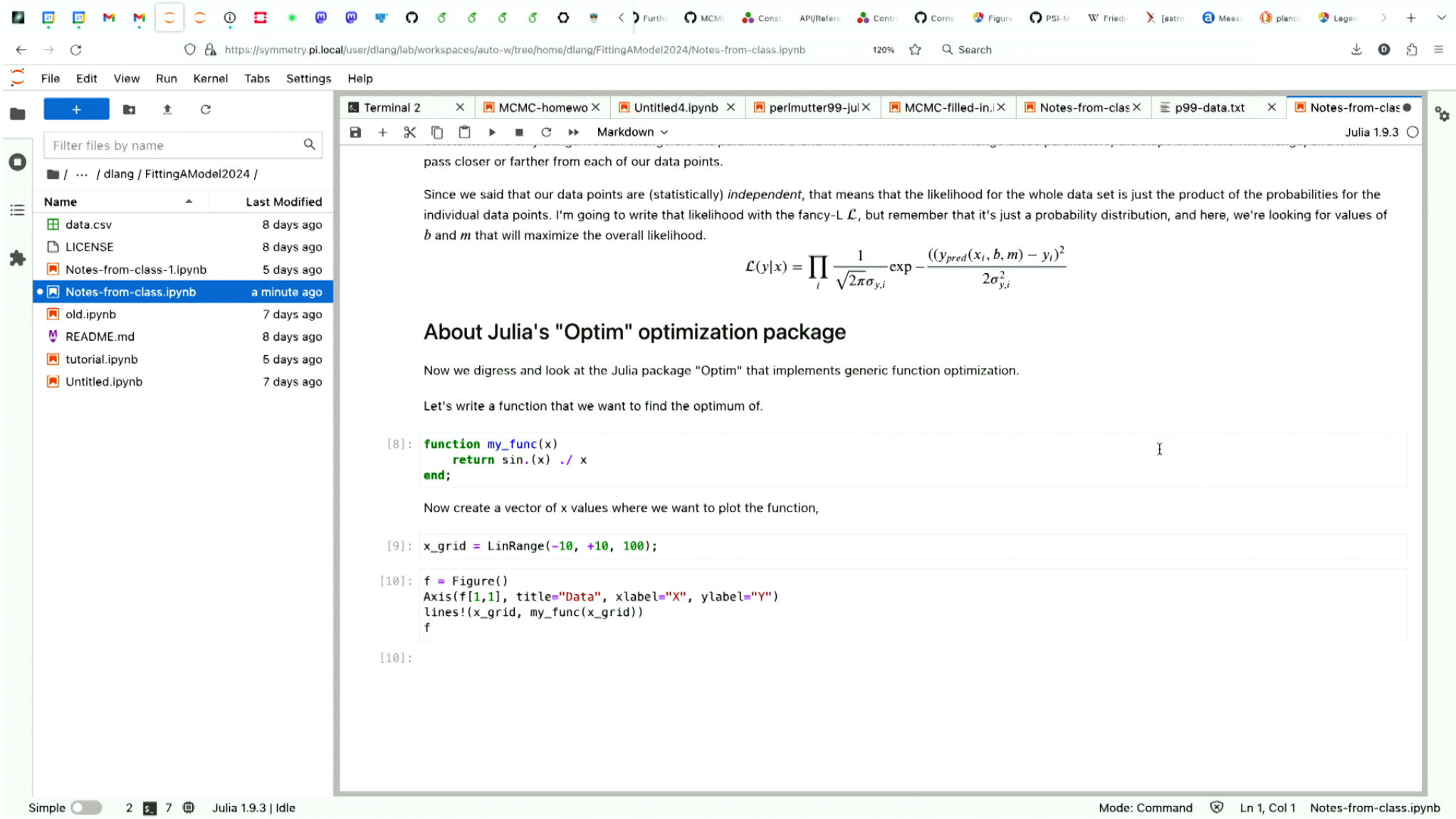
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pass closer or farther from each of our data points.
Since we said that our data points are (statistically) independent, that means that the likelihood for the whole data set is just the product of the probabilities for the individual data points. I'm going to write that likelihood with the fancy-L $\mathcal{L}$, but remember that it's just a probability distribution, and here, we're looking for values of b and m that will maximize the overall likelihood.
$$\mathcal{L}(y|x) = \prod_i \frac{1}{\sqrt{2\pi}\sigma_{y,i}} \exp - \frac{((y_{pred}(x_i, b, m) - y_i)^2}{2\sigma_{y,i}^2}$$
About Julia's "Optim" optimization package
Now we digress and look at the Julia package "Optim" that implements generic function optimization.
Let's write a function that we want to find the optimum of.
[8]:
function my_func(x)
return sin.(x) ./ x
end;
Now create a vector of x values where we want to plot the function,
[9]:
x_grid = LinRange(-10, +10, 100);
[10]:
f = Figure()
Axis(f[1,1], title="Data", xlabel="X", ylabel="Y")
lines!(x_grid, my_func(x_grid))
f
[10]:
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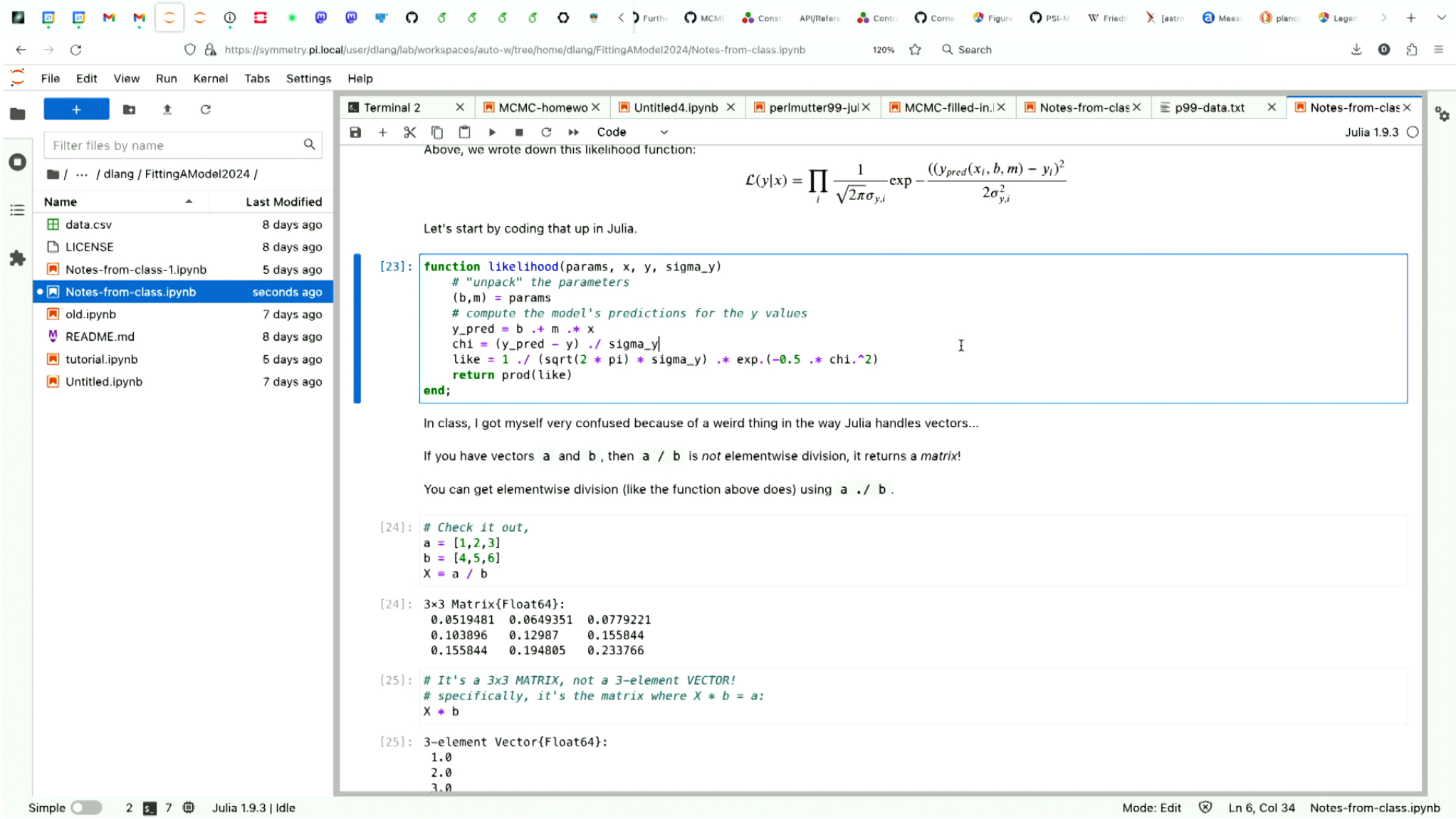
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Above, we wrote down this likelihood function:
$$\mathcal{L}(y|x) = \prod_i \frac{1}{\sqrt{2\pi}\sigma_{y,i}} \exp - \frac{((y_{pred}(x_i, b, m) - y_i)^2}{2\sigma_{y,i}^2}$$
Let's start by coding that up in Julia.
[23]:
function likelihood(params, x, y, sigma_y)
"unpack" the parameters
(b,m) = params
# compute the model's predictions for the y values
y_pred = b .+ m .* x
chi = (y_pred - y) ./ sigma_y
like = 1 ./ (sqrt(2 * pi) * sigma_y) .* exp.(-0.5 .* chi.^2)
return prod(like)
end;
In class, I got myself very confused because of a weird thing in the way Julia handles vectors...
If you have vectors a and b, then a / b is not elementwise division, it returns a matrix!
You can get elementwise division (like the function above does) using a ./ b.
[24]:
# Check it out,
a = [1,2,3]
b = [4,5,6]
X = a / b
[24]:
3×3 Matrix{Float64}:
0.0519481 0.0649351 0.0779221
0.103896 0.12987 0.155844
0.155844 0.194805 0.233766
[25]:
It's a 3x3 MATRIX, not a 3-element VECTOR!
specifically, it's the matrix where X * b = a:
X * b
[25]:
3-element Vector{Float64}:
1.0
2.0
3.0
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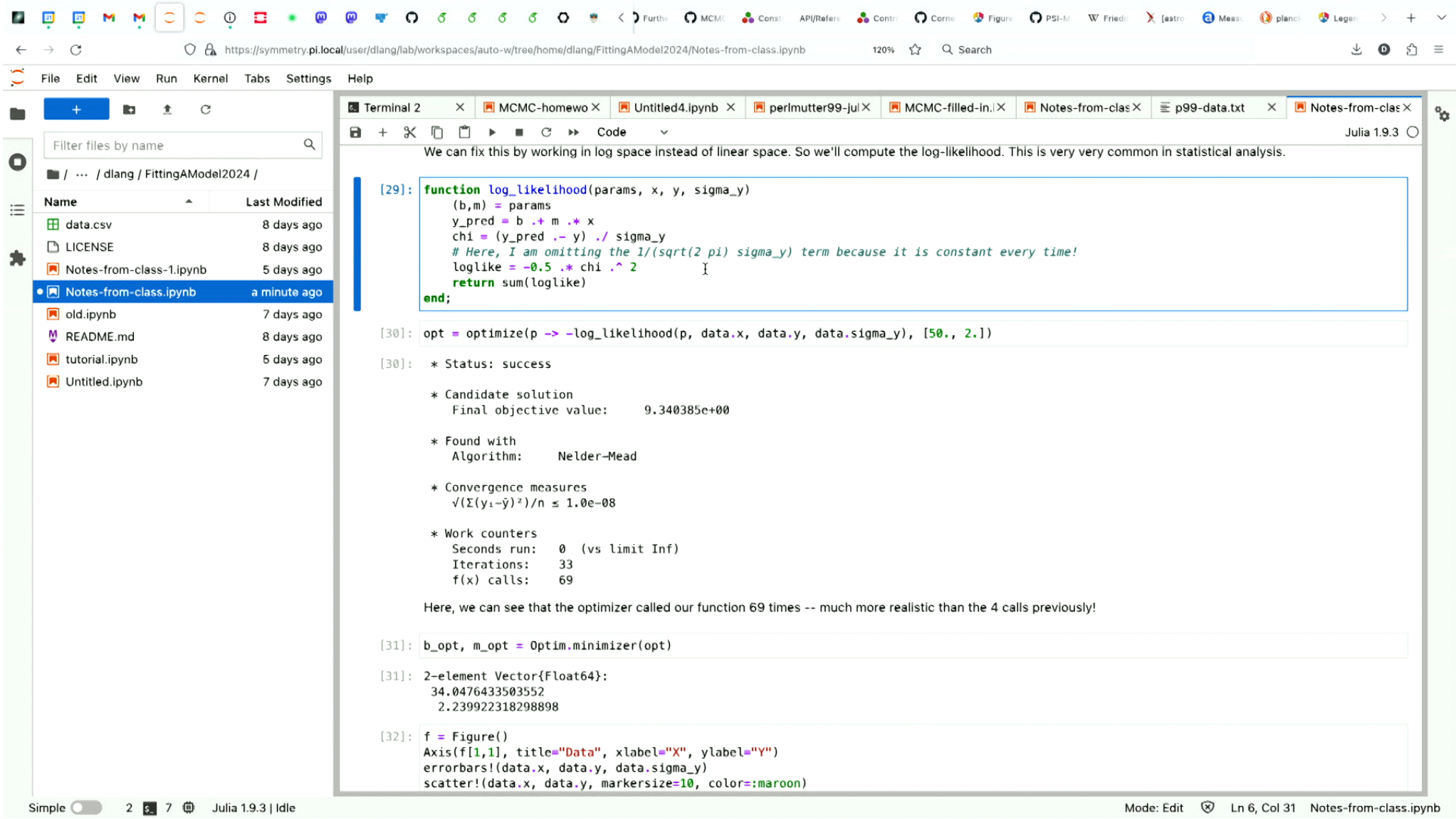
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We can fix this by working in log space instead of linear space. So we'll compute the log-likelihood. This is very very common in statistical analysis.
[29]:
function log_likelihood(params, x, y, sigma_y)
(b,m) = params
y_pred = b .+ m .* x
chi = (y_pred .- y) ./ sigma_y
# Here, I am omitting the 1/(sqrt(2 pi) sigma_y) term because it is constant every time!
loglike = -0.5 .* chi .^ 2
return sum(loglike)
end;
[30]:
opt = optimize(p -> -log_likelihood(p, data.x, data.y, data.sigma_y), [50., 2.])
[30]:
* Status: success
* Candidate solution
Final objective value: 9.340385e+00
* Found with
Algorithm: Nelder-Mead
* Convergence measures
√(Σ(yᵢ-ȳ)²)/n ≤ 1.0e-08
* Work counters
Seconds run: 0 (vs limit Inf)
Iterations: 33
f(x) calls: 69
Here, we can see that the optimizer called our function 69 times -- much more realistic than the 4 calls previously!
[31]:
b_opt, m_opt = Optim.minimizer(opt)
[31]:
2-element Vector{Float64}:
34.0476433503552
2.239922318298898
[32]:
f = Figure()
Axis(f[1,1], title="Data", xlabel="X", ylabel="Y")
errorbars!(data.x, data.y, data.sigma_y)
scatter!(data.x, data.y, markersize=10, color=:maroon)
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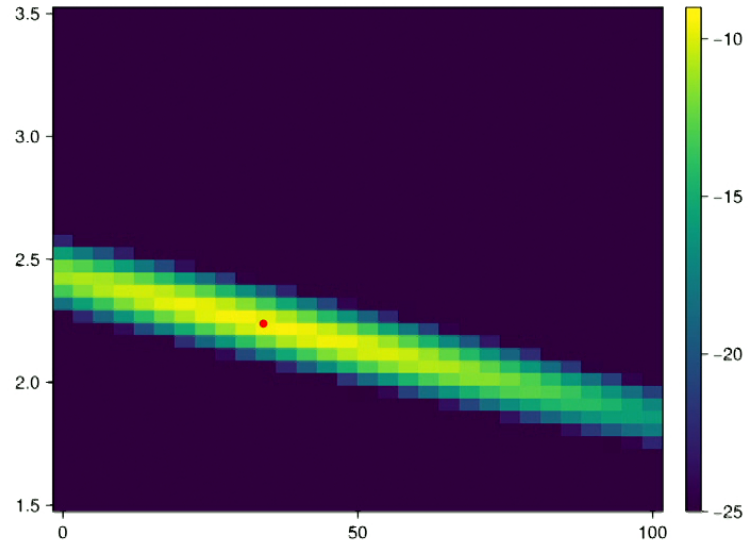
[34]:
```
-9.363035567226113
```

[35]:
```
fig, ax, hm = heatmap(b_grid, m_grid, ll_grid, colorrange=(-25, -9))
Colorbar(fig[:, end+1], hm)
scatter!(b_opt, m_opt, color=:red)
fig
```

[35]:



Here, we can see that the `b` and `m` parameters are quite strongly (anti)correlated.

We can also plot the contours in this log-probability space:

[36]:
```
f = Figure()
```

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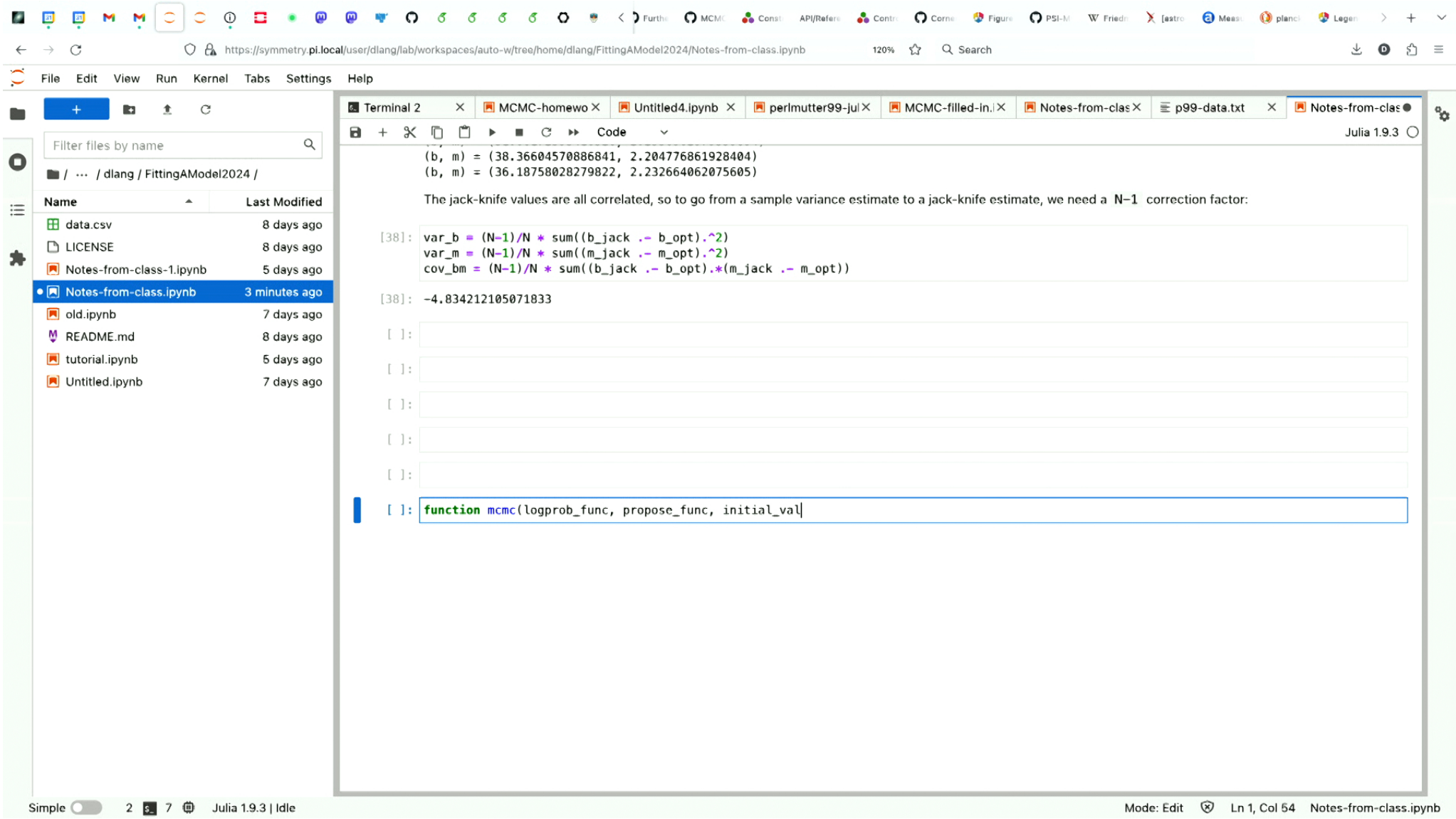
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(b, m) = (38.36604570886841, 2.204776861928404)
(b, m) = (36.18758028279822, 2.232664062075605)
The jack-knife values are all correlated, so to go from a sample variance estimate to a jack-knife estimate, we need a N-1 correction factor:
[38]: var_b = (N-1)/N * sum((b_jack .- b_opt).^2)
var_m = (N-1)/N * sum((m_jack .- m_opt).^2)
cov_bm = (N-1)/N * sum((b_jack .- b_opt).*(m_jack .- m_opt))
[38]: -4.834212105071833
[ ]:
[ ]:
[ ]:
[ ]:
[ ]:
[ ]: function mcmc(logprob_func, propose_func, initial_val
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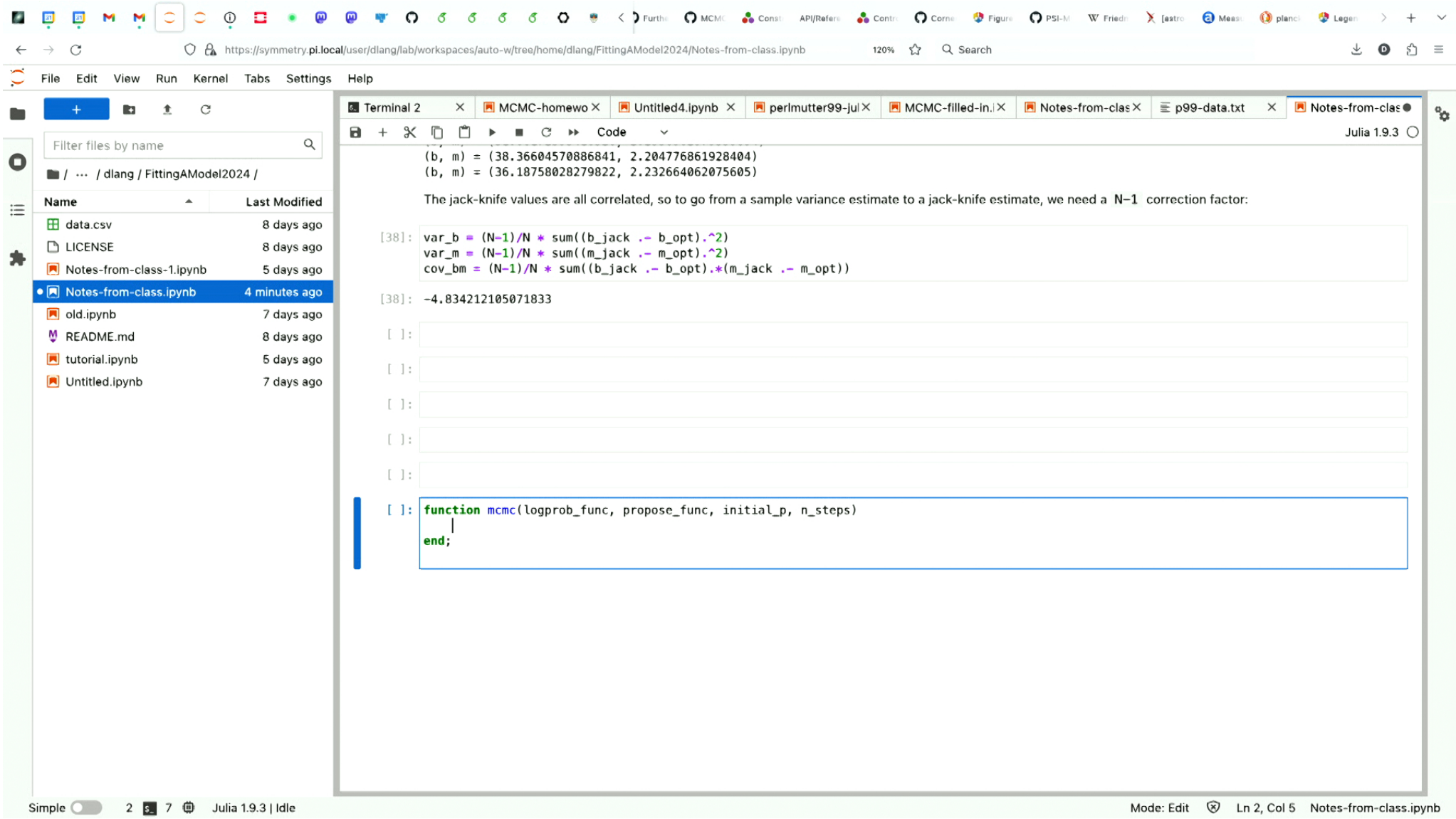
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var_m = (N-1)/N * sum((m_jack .- m_opt).^2)
cov_bm = (N-1)/N * sum((b_jack .- b_opt).*(m_jack .- m_opt))
[38]: -4.834212105071833
[ ]:
[ ]:
[ ]:
[ ]:
[ ]:
[ ]:
function mcmc(logprob_func, propose_func, initial_p, n_steps)
end;
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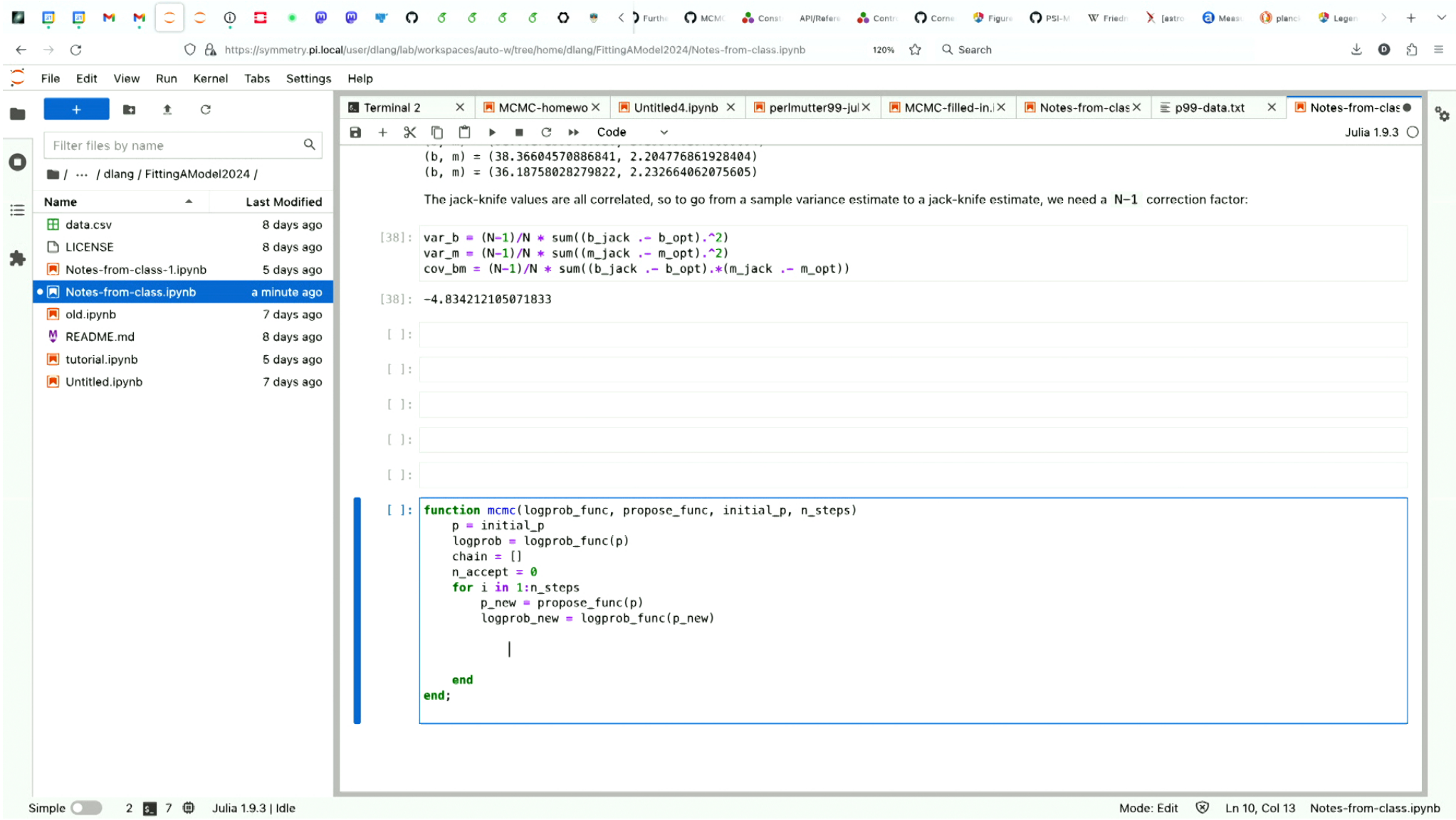
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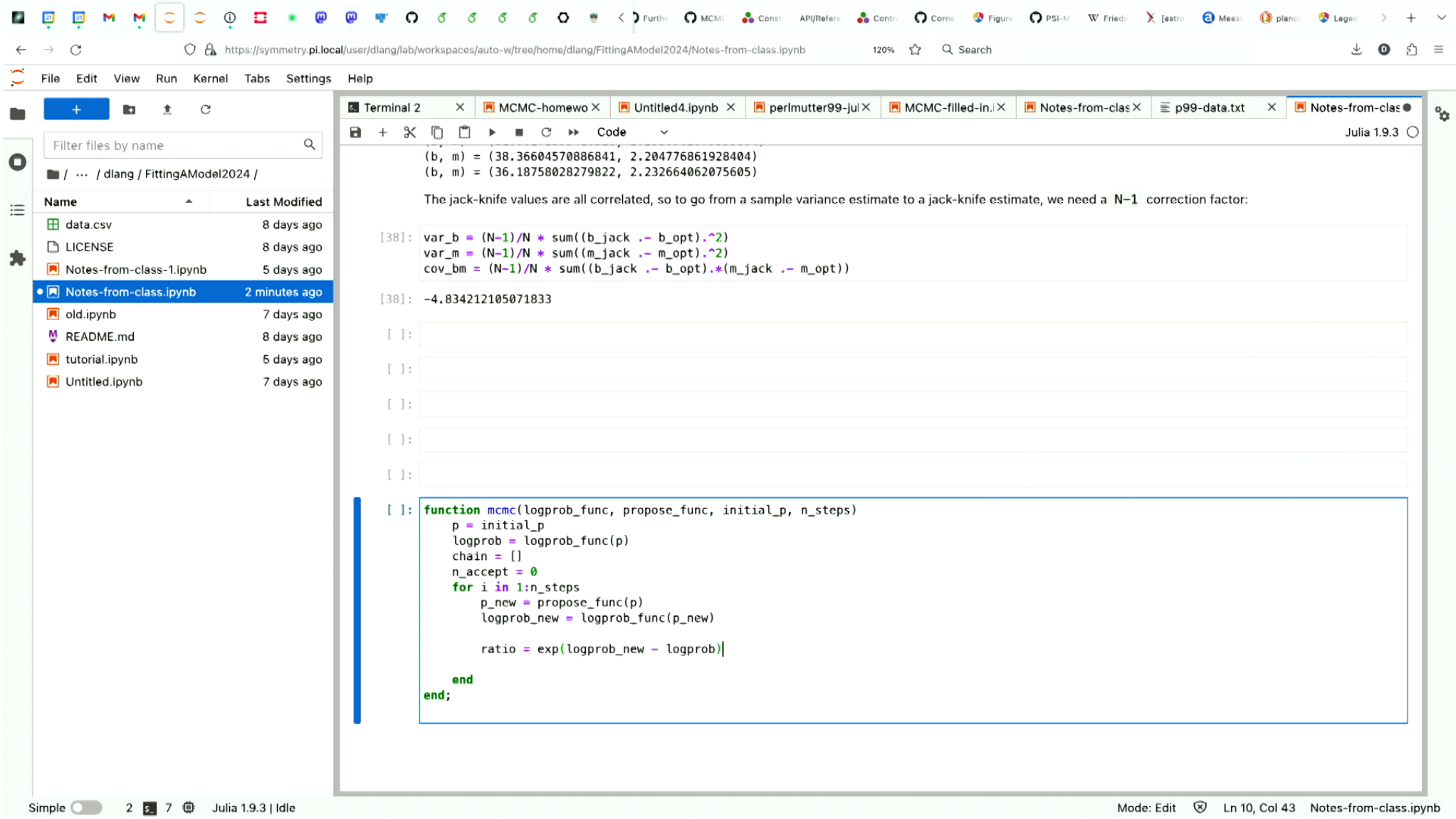
Notes-from-class.ipynb a minute ago
old.ipynb 7 days ago
README.md 8 days ago
tutorial.ipynb 5 days ago
Untitled.ipynb 7 days ago
Terminal 2
MCMC-homewo
Untitled4.ipynb
perlmutter99-jul
MCMC-filled-in.
Notes-from-clas
p99-data.txt
Notes-from-clas
Code
Julia 1.9.3
(b, m) = (38.36604570886841, 2.204776861928404)
(b, m) = (36.18758028279822, 2.232664062075605)
The jack-knife values are all correlated, so to go from a sample variance estimate to a jack-knife estimate, we need a N-1 correction factor:
[38]:
var_b = (N-1)/N * sum((b_jack .- b_opt).^2)
var_m = (N-1)/N * sum((m_jack .- m_opt).^2)
cov_bm = (N-1)/N * sum((b_jack .- b_opt).*(m_jack .- m_opt))
[38]:
-4.834212105071833
[ ]:
[ ]:
[ ]:
[ ]:
[ ]:
[ ]:
function mcmc(logprob_func, propose_func, initial_p, n_steps)
p = initial_p
logprob = logprob_func(p)
chain = []
n_accept = 0
for i in 1:n_steps
p_new = propose_func(p)
logprob_new = logprob_func(p_new)
end
end;
Simple
2 7
Julia 1.9.3 | Idle
Mode: Edit
Ln 10, Col 13
Notes-from-class.ipynb


https://symmetry.pi.local/user/dlang/lab/workspaces/auto-w/tree/home/dlang/FittingAModel2024/Notes-from-class.ipynb
File Edit View Run Kernel Tabs Settings Help
Terminal 2
MCMC-homewo
Untitled4.ipynb
perlmutter99-jul
MCMC-filled-in.
Notes-from-clas
p99-data.txt
Notes-from-clas
Code
Julia 1.9.3
Filter files by name
/ ··· / dlang / FittingAModel2024 /
Name
Last Modified
data.csv 8 days ago
LICENSE 8 days ago
Notes-from-class-1.ipynb 5 days ago
Notes-from-class.ipynb 2 minutes ago
old.ipynb 7 days ago
README.md 8 days ago
tutorial.ipynb 5 days ago
Untitled.ipynb 7 days ago
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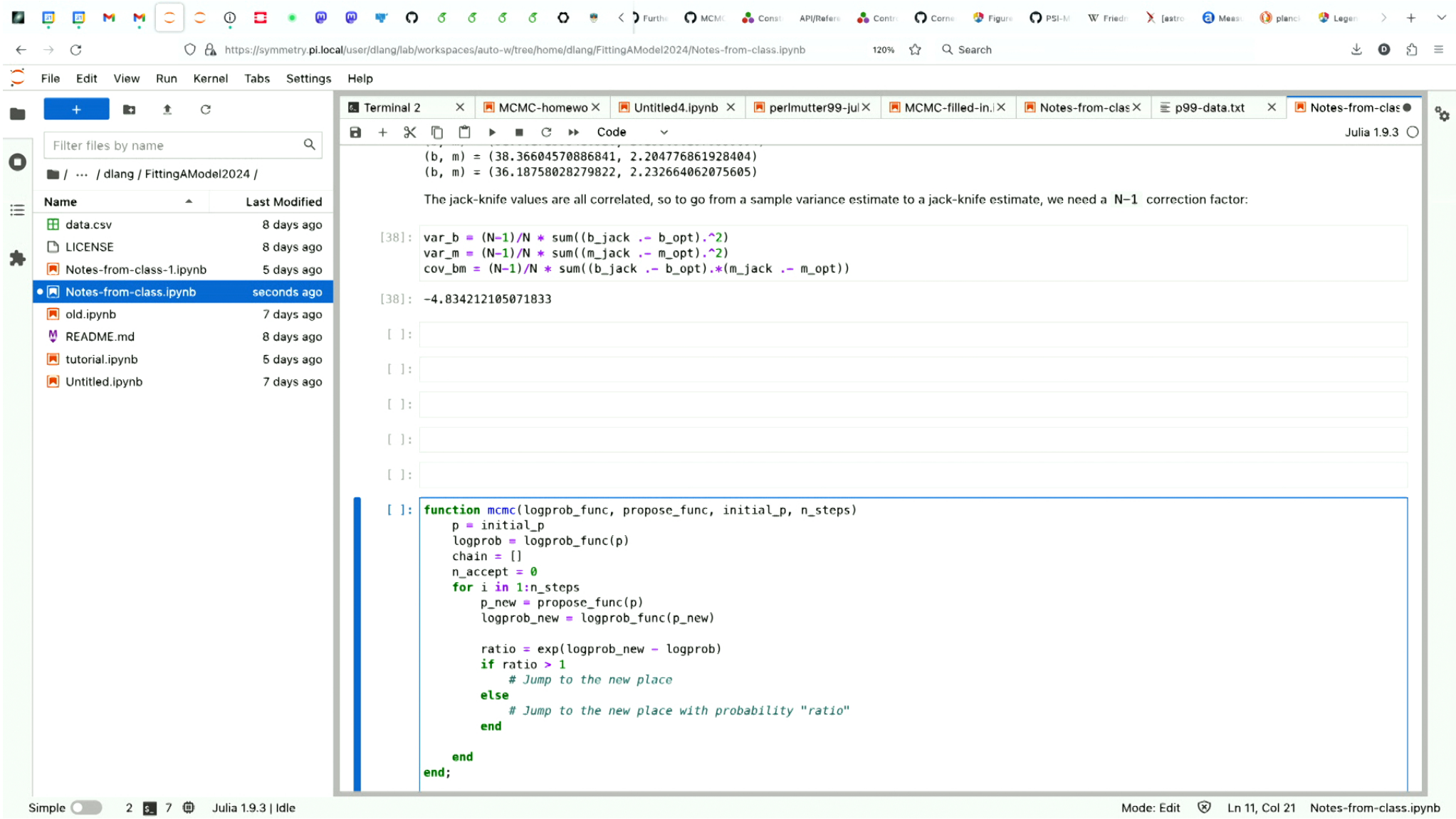
cov_bm = (N-1)/N * sum((b_jack .- b_opt).*(m_jack .- m_opt))
[38]:
-4.834212105071833
[ ]:
[ ]:
[ ]:
[ ]:
[ ]:
[ ]:
function mcmc(logprob_func, propose_func, initial_p, n_steps)
p = initial_p
logprob = logprob_func(p)
chain = []
n_accept = 0
for i in 1:n_steps
p_new = propose_func(p)
logprob_new = logprob_func(p_new)
ratio = exp(logprob_new - logprob)
end
end;
Simple
Julia 1.9.3 | Idle
Mode: Edit
Ln 10, Col 43
Notes-from-class.ipynb


https://symmetry.pi.local/user/dlang/lab/workspaces/auto-w/tree/home/dlang/FittingAModel2024/Notes-from-class.ipynb
File Edit View Run Kernel Tabs Settings Help
Terminal 2
MCMC-homewo
Untitled4.ipynb
perlmutter99-jul
MCMC-filled-in.
Notes-from-clas
p99-data.txt
Notes-from-clas
Code
Julia 1.9.3
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Name
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data.csv 8 days ago
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Notes-from-class-1.ipynb 5 days ago
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old.ipynb 7 days ago
README.md 8 days ago
tutorial.ipynb 5 days ago
Untitled.ipynb 7 days ago
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cov_bm = (N-1)/N * sum((b_jack .- b_opt).*(m_jack .- m_opt))
[38]: -4.834212105071833
[ ]:
[ ]:
[ ]:
[ ]:
[ ]:
[ ]:
function mcmc(logprob_func, propose_func, initial_p, n_steps)
p = initial_p
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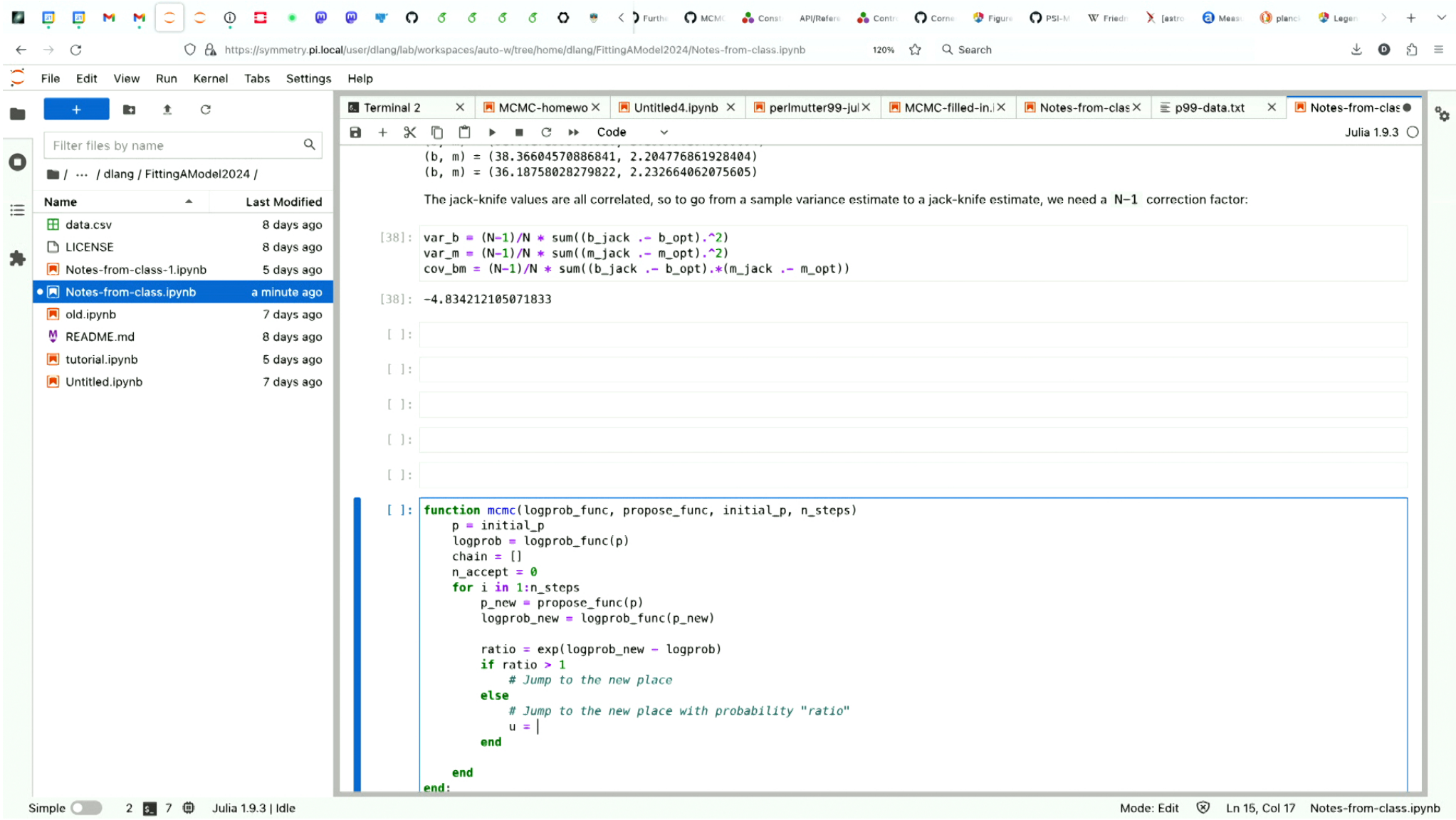
chain = []
n_accept = 0
for i in 1:n_steps
p_new = propose_func(p)
logprob_new = logprob_func(p_new)
ratio = exp(logprob_new - logprob)
if ratio > 1
# Jump to the new place
else
# Jump to the new place with probability "ratio"
end
end
end;
Simple 2 7 Julia 1.9.3 | Idle
Mode: Edit Ln 11, Col 21 Notes-from-class.ipynb


https://symmetry.pi.local/user/dlang/lab/workspaces/auto-w/tree/home/dlang/FittingAModel2024/Notes-from-class.ipynb
File Edit View Run Kernel Tabs Settings Help
Terminal 2
MCMC-homewo
Untitled4.ipynb
perlmutter99-jul
MCMC-filled-in.
Notes-from-clas
p99-data.txt
Notes-from-clas
Code
Julia 1.9.3
Filter files by name
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Name
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data.csv 8 days ago
LICENSE 8 days ago
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Notes-from-class.ipynb a minute ago
old.ipynb 7 days ago
README.md 8 days ago
tutorial.ipynb 5 days ago
Untitled.ipynb 7 days ago
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cov_bm = (N-1)/N * sum((b_jack .- b_opt).*(m_jack .- m_opt))
[38]: -4.834212105071833
[ ]:
[ ]:
[ ]:
[ ]:
[ ]:
[ ]:
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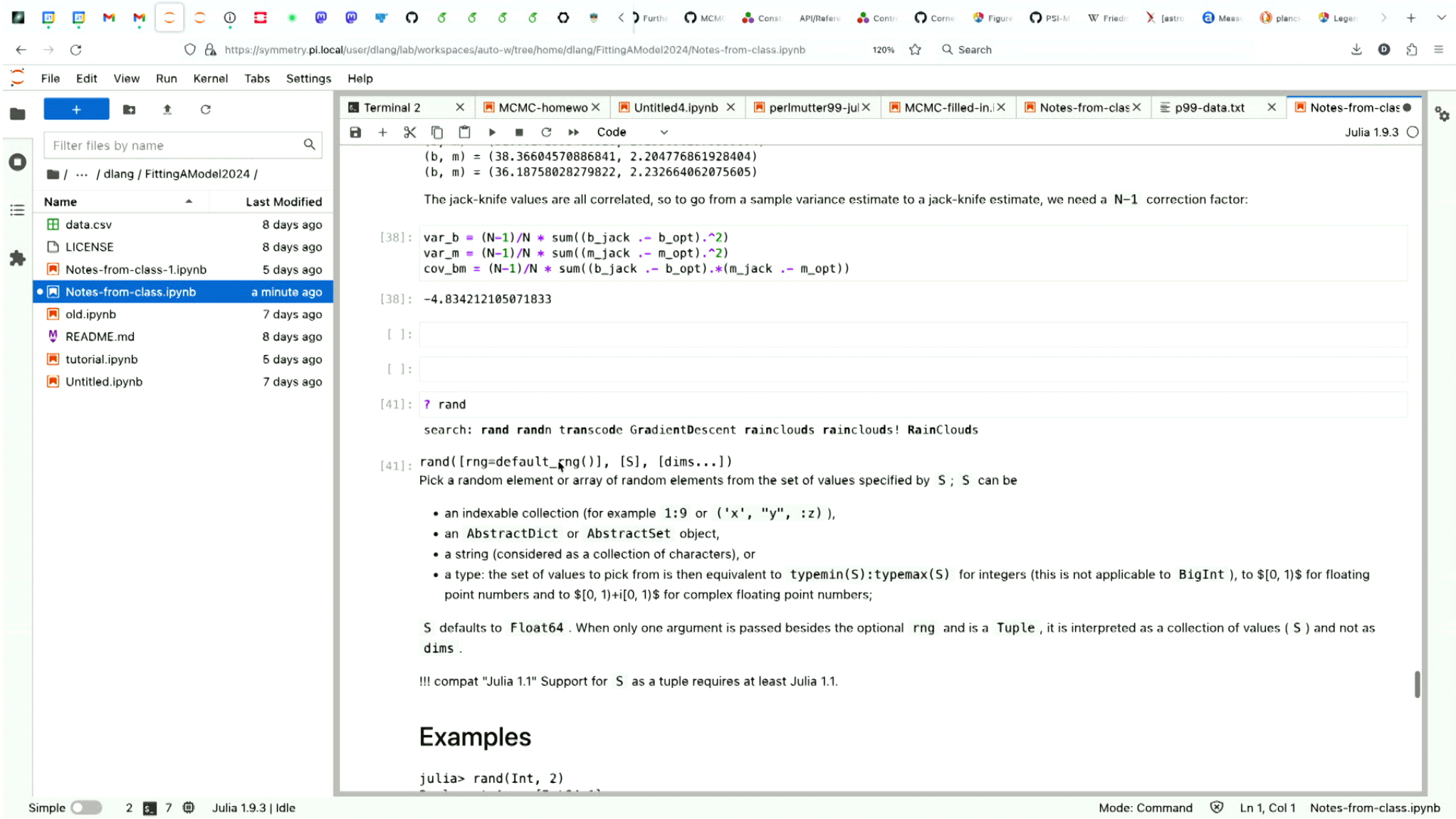
p = initial_p
logprob = logprob_func(p)
chain = []
n_accept = 0
for i in 1:n_steps
p_new = propose_func(p)
logprob_new = logprob_func(p_new)
ratio = exp(logprob_new - logprob)
if ratio > 1
# Jump to the new place
else
# Jump to the new place with probability "ratio"
u =
end
end
end;
Simple 2 7 Julia 1.9.3 | Idle
Mode: Edit Ln 15, Col 17 Notes-from-class.ipynb


https://symmetry.pi.local/user/dlang/lab/workspaces/auto-w/tree/home/dlang/FittingAModel2024/Notes-from-class.ipynb
File Edit View Run Kernel Tabs Settings Help
Terminal 2
MCMC-homewo
Untitled4.ipynb
perlmutter99-jul
MCMC-filled-in.
Notes-from-clas
p99-data.txt
Notes-from-clas
Code
Julia 1.9.3
Filter files by name
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Name
Last Modified
data.csv 8 days ago
LICENSE 8 days ago
Notes-from-class-1.ipynb 5 days ago
Notes-from-class.ipynb a minute ago
old.ipynb 7 days ago
README.md 8 days ago
tutorial.ipynb 5 days ago
Untitled.ipynb 7 days ago
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cov_bm = (N-1)/N * sum((b_jack .- b_opt).*(m_jack .- m_opt))
[38]:
-4.834212105071833
[ ]:
[ ]:
[41]:
? rand
search: rand randn transcode GradientDescent rainclouds rainclouds! RainClouds
[41]:
rand([rng=default_rng()], [S], [dims...])
Pick a random element or array of random elements from the set of values specified by S ; S can be
an indexable collection (for example 1:9 or ('x', "y", :z)),
an AbstractDict or AbstractSet object,
a string (considered as a collection of characters), or
a type: the set of values to pick from is then equivalent to typemin(S):typemax(S) for integers (this is not applicable to BigInt), to $[0, 1)$ for floating point numbers and to $[0, 1)+i[0, 1)$ for complex floating point numbers;
S defaults to Float64 . When only one argument is passed besides the optional rng and is a Tuple , it is interpreted as a collection of values (S) and not as dims .
!!! compat "Julia 1.1" Support for S as a tuple requires at least Julia 1.1.
Examples
julia> rand(Int, 2)
Simple
2 7
Julia 1.9.3 | Idle
Mode: Command
Ln 1, Col 1
Notes-from-class.ipynb

https://symmetry.pi.local/user/dlang/lab/workspaces/auto-w/tree/home/dlang/FittingAModel2024/Notes-from-class.ipynb

File Edit View Run Kernel Tabs Settings Help

Terminal 2 | MCMC-homewo | Untitled4.ipynb | perlmutter99-jul | MCMC-filled-in. | Notes-from-clas | p99-data.txt | Notes-from-clas

Code Julia 1.9.3

Filter files by name

/ ··· / dlang / FittingAModel2024 /

Name	Last Modified
data.csv	8 days ago
LICENSE	8 days ago
Notes-from-class-1.ipynb	5 days ago
Notes-from-class.ipynb	2 minutes ago
old.ipynb	7 days ago
README.md	8 days ago
tutorial.ipynb	5 days ago
Untitled.ipynb	7 days ago

The jack-knife values are all correlated, so to go from a sample variance estimate to a jack-knife estimate, we need a N−1 correction factor:

[38]:
```
var_b = (N-1)/N * sum((b_jack .- b_opt).^2)
var_m = (N-1)/N * sum((m_jack .- m_opt).^2)
cov_bm = (N-1)/N * sum((b_jack .- b_opt).*(m_jack .- m_opt))
```

[38]:
```
-4.834212105071833
```

[ ]:

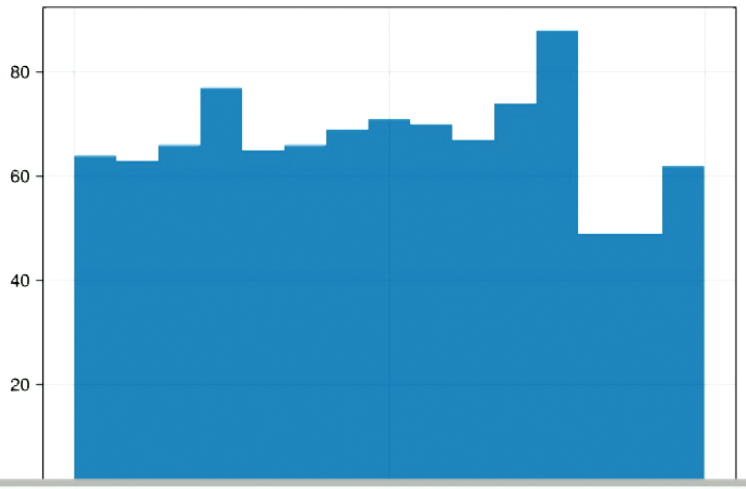
[ ]:

[46]:
```
rand()
```

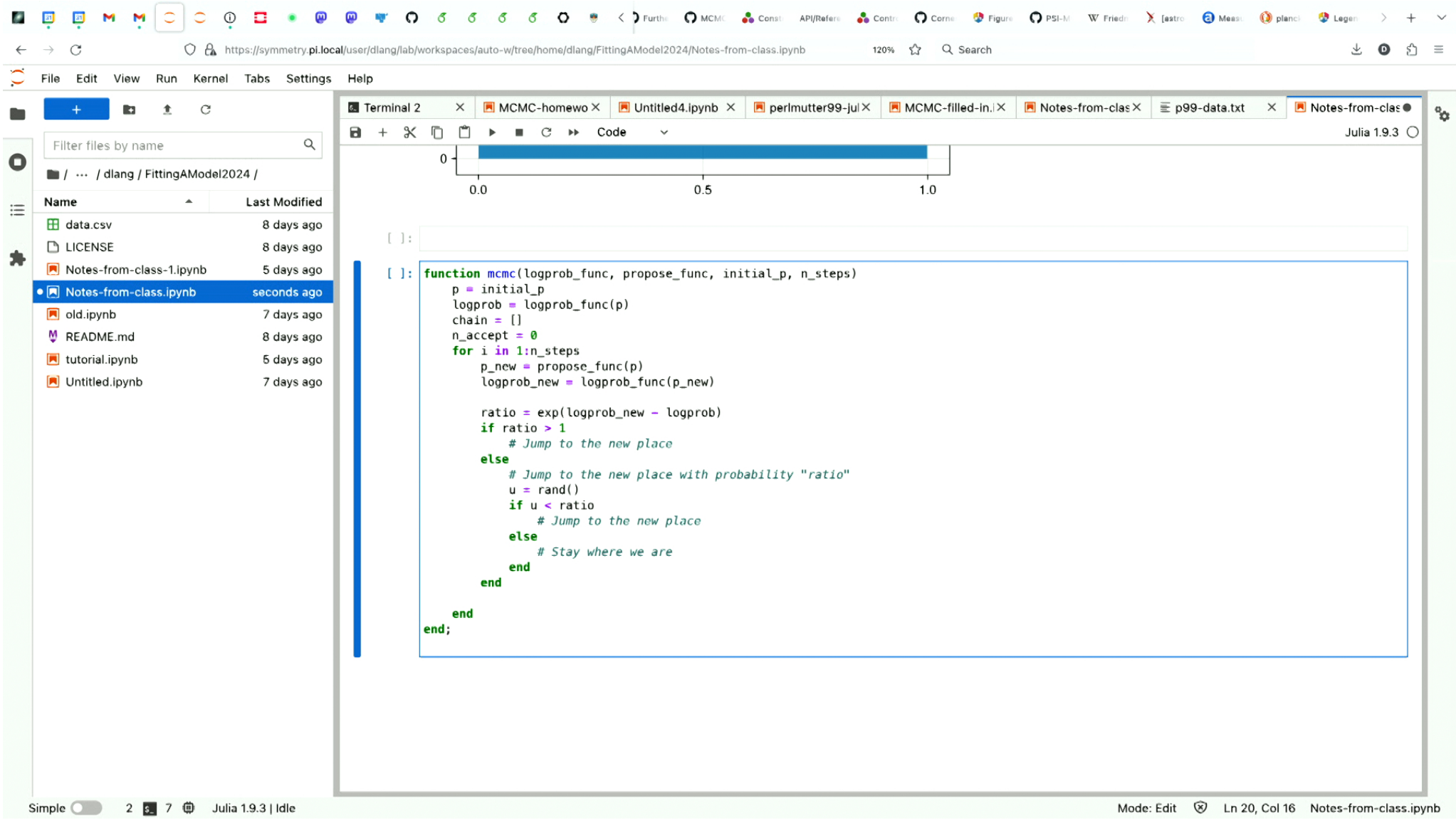
[46]:
```
0.32329600582988793
```

[47]:
```
hist(rand(1000))
```

[47]:



Simple 2 7 Julia 1.9.3 | Idle Saving started Mode: Command Ln 1, Col 1 Notes-from-class.ipynb


https://symmetry.pi.local/user/dlang/lab/workspaces/auto-w/tree/home/dlang/FittingAModel2024/Notes-from-class.ipynb
File Edit View Run Kernel Tabs Settings Help
Terminal 2
MCMC-homewo
Untitled4.ipynb
perlmutter99-jul
MCMC-filled-in.
Notes-from-clas
p99-data.txt
Notes-from-clas
Code
Julia 1.9.3
Filter files by name
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tutorial.ipynb 5 days ago
Untitled.ipynb 7 days ago
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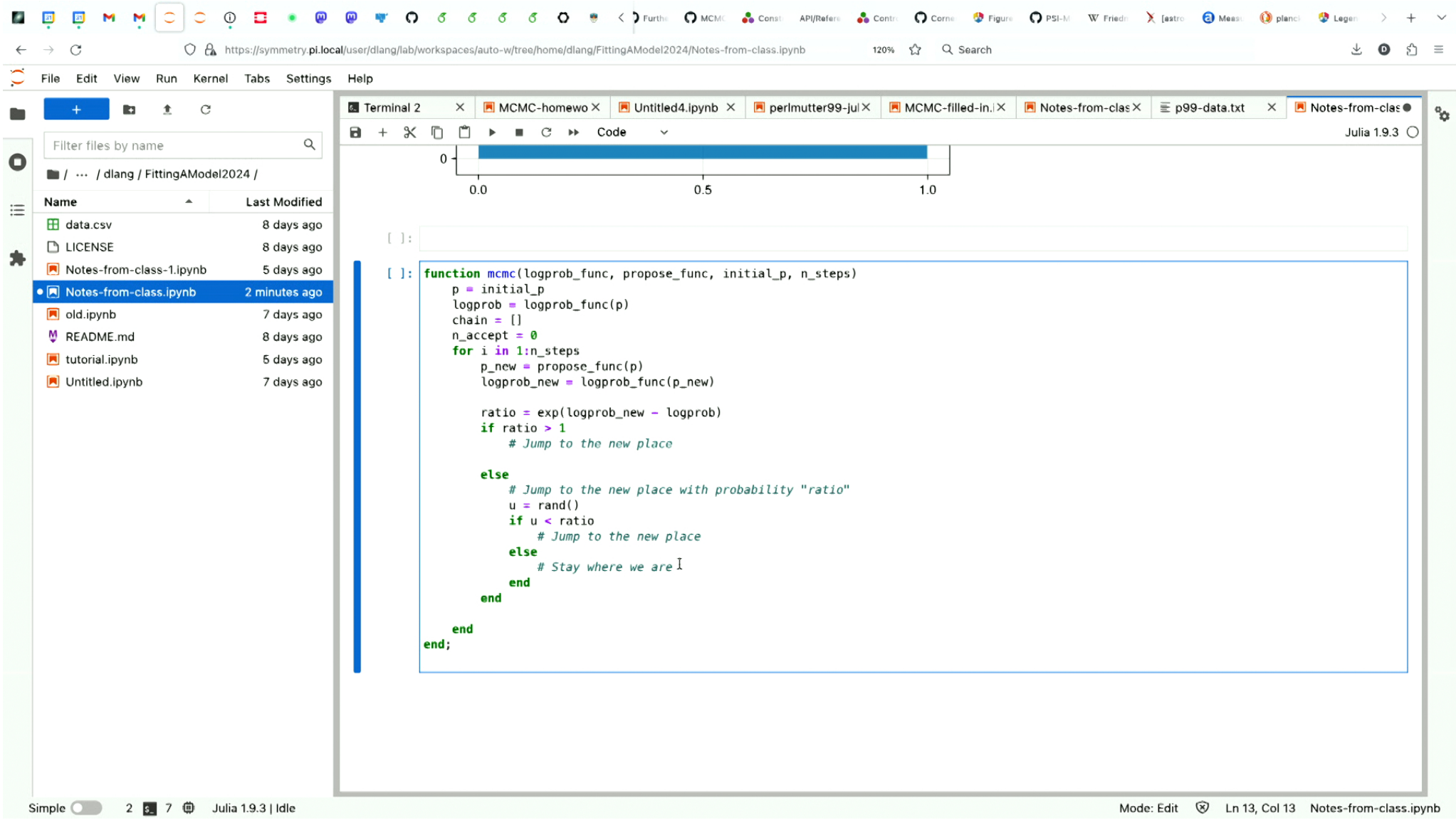
[ ]:
[ ]:
function mcmc(logprob_func, propose_func, initial_p, n_steps)
p = initial_p
logprob = logprob_func(p)
chain = []
n_accept = 0
for i in 1:n_steps
p_new = propose_func(p)
logprob_new = logprob_func(p_new)
ratio = exp(logprob_new - logprob)
if ratio > 1
# Jump to the new place
else
# Jump to the new place with probability "ratio"
u = rand()
if u < ratio
# Jump to the new place
else
# Stay where we are
end
end
end
end;
Simple
2 7
Julia 1.9.3 | Idle
Mode: Edit
Ln 20, Col 16
Notes-from-class.ipynb


https://symmetry.pi.local/user/dlang/lab/workspaces/auto-w/tree/home/dlang/FittingAModel2024/Notes-from-class.ipynb
File Edit View Run Kernel Tabs Settings Help
Filter files by name
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Terminal 2
MCMC-homewo
Untitled4.ipynb
perlmutter99-jul
MCMC-filled-in.
Notes-from-clas
p99-data.txt
Notes-from-clas
Code
Julia 1.9.3
0
0.0
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1.0
[ ]:
[ ]:
function mcmc(logprob_func, propose_func, initial_p, n_steps)
p = initial_p
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for i in 1:n_steps
p_new = propose_func(p)
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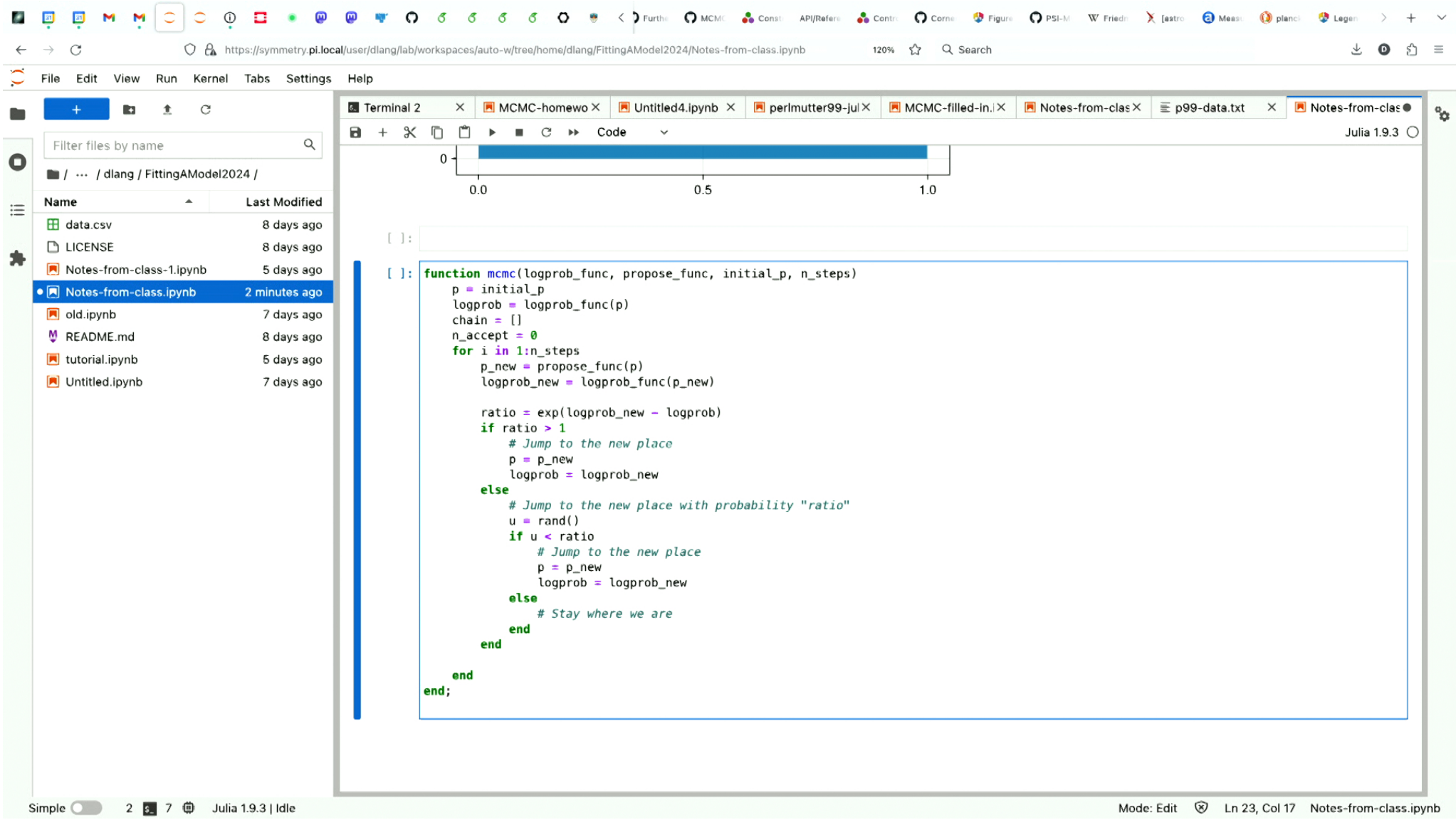
ratio = exp(logprob_new - logprob)
if ratio > 1
# Jump to the new place
else
# Jump to the new place with probability "ratio"
u = rand()
if u < ratio
# Jump to the new place
else
# Stay where we are
end
end
end
end;
Simple
2 7
Julia 1.9.3 | Idle
Mode: Edit
Ln 13, Col 13
Notes-from-class.ipynb


https://symmetry.pi.local/user/dlang/lab/workspaces/auto-w/tree/home/dlang/FittingAModel2024/Notes-from-class.ipynb
File Edit View Run Kernel Tabs Settings Help
Terminal 2
MCMC-homewo
Untitled4.ipynb
perlmutter99-jul
MCMC-filled-in.
Notes-from-clas
p99-data.txt
Notes-from-clas
Code
Julia 1.9.3
Filter files by name
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tutorial.ipynb 5 days ago
Untitled.ipynb 7 days ago
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[ ]:
[ ]:
function mcmc(logprob_func, propose_func, initial_p, n_steps)
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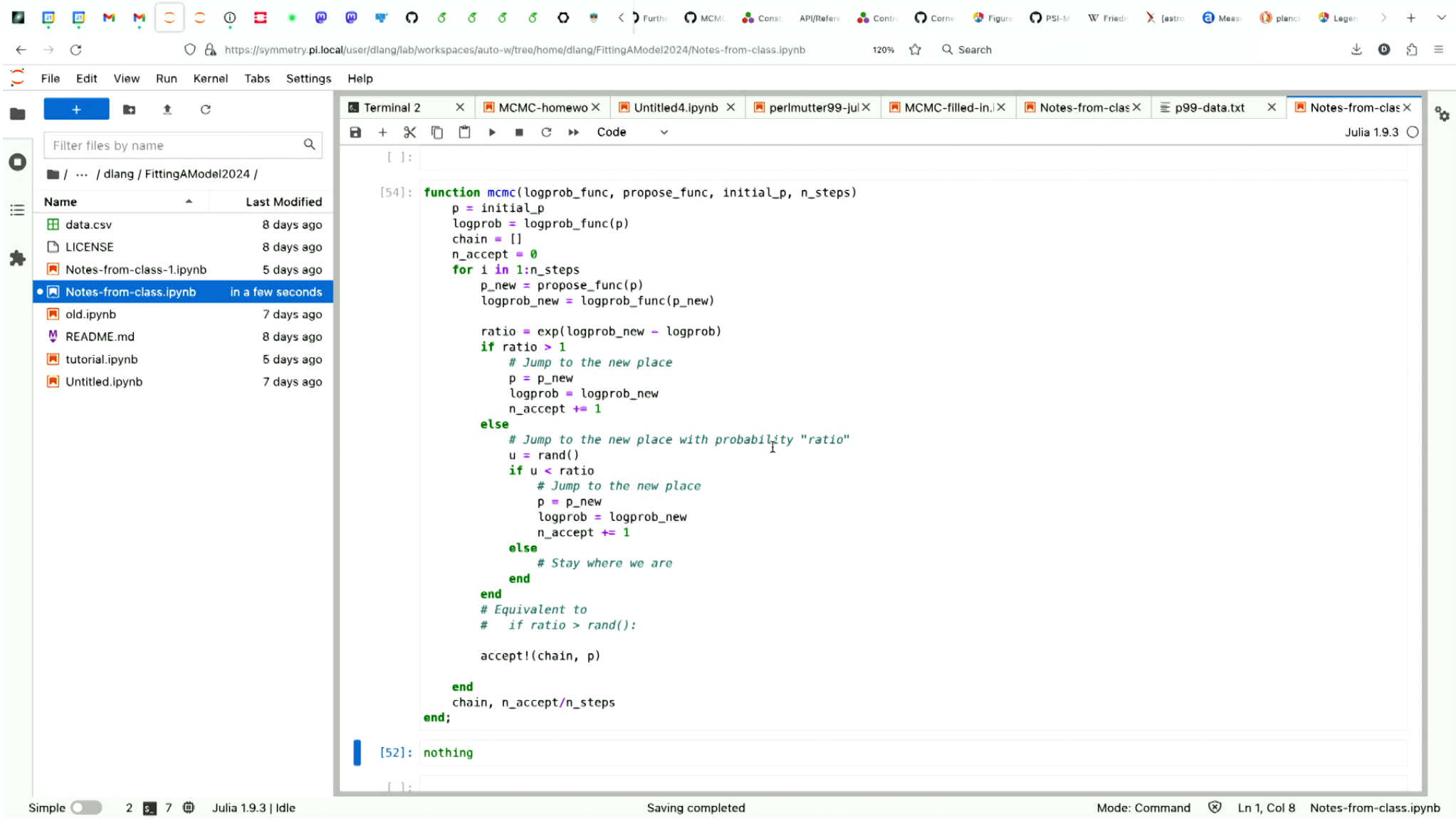
if ratio > 1
# Jump to the new place
p = p_new
logprob = logprob_new
else
# Jump to the new place with probability "ratio"
u = rand()
if u < ratio
# Jump to the new place
p = p_new
logprob = logprob_new
else
# Stay where we are
end
end
end
end;
Simple
2 7
Julia 1.9.3 | Idle
Mode: Edit
Ln 23, Col 17
Notes-from-class.ipynb


https://symmetry.pi.local/user/dlang/lab/workspaces/auto-w/tree/home/dlang/FittingAModel2024/Notes-from-class.ipynb
File Edit View Run Kernel Tabs Settings Help
Terminal 2
MCMC-homewo
Untitled4.ipynb
perlmutter99-jul
MCMC-filled-in.
Notes-from-clas
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Notes-from-clas
Filter files by name
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Name
Last Modified
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LICENSE 8 days ago
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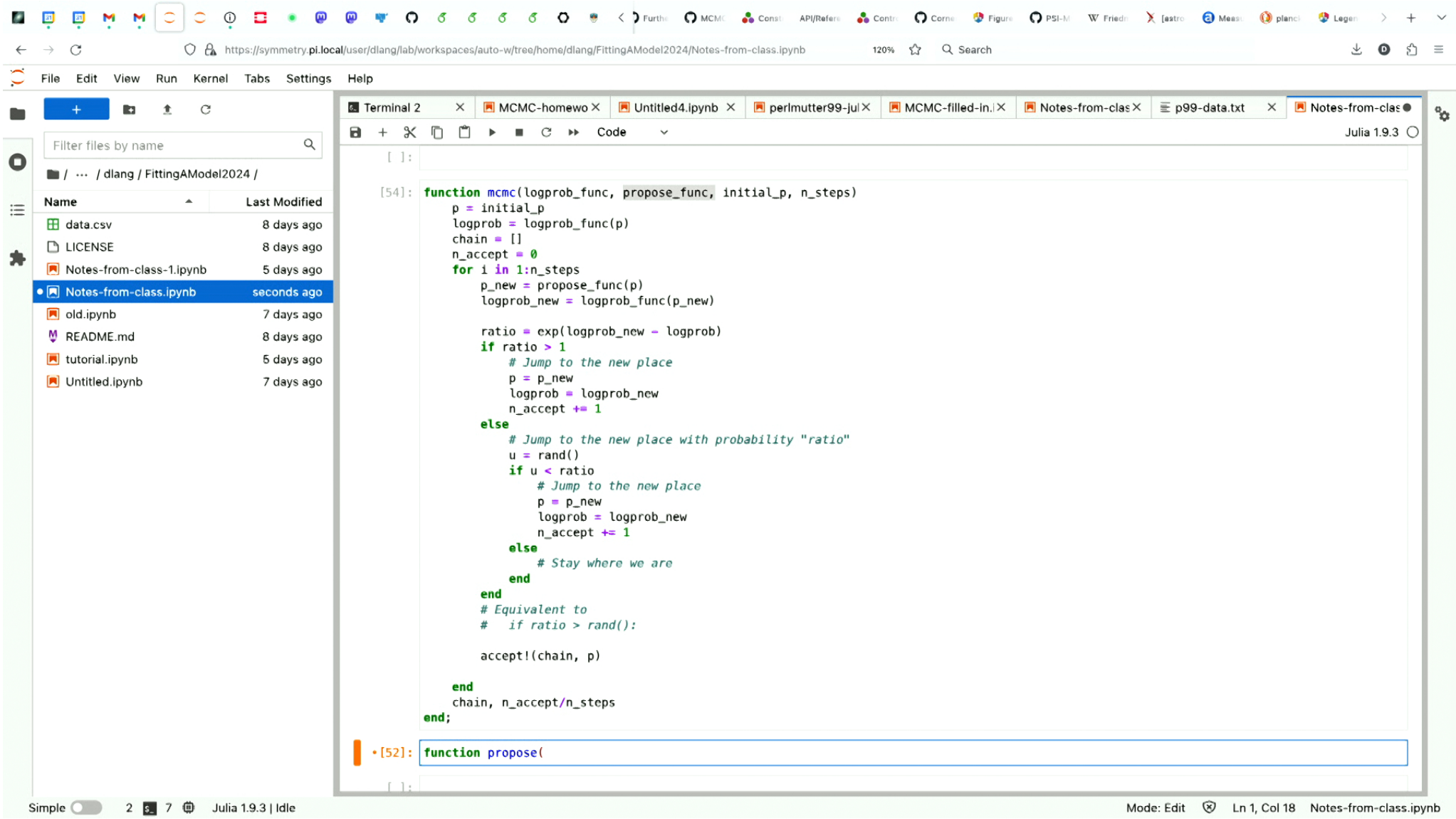
old.ipynb 7 days ago
README.md 8 days ago
tutorial.ipynb 5 days ago
Untitled.ipynb 7 days ago
Code
Julia 1.9.3
[ ]:
[54]:
function mcmc(logprob_func, propose_func, initial_p, n_steps)
p = initial_p
logprob = logprob_func(p)
chain = []
n_accept = 0
for i in 1:n_steps
p_new = propose_func(p)
logprob_new = logprob_func(p_new)
ratio = exp(logprob_new - logprob)
if ratio > 1
# Jump to the new place
p = p_new
logprob = logprob_new
n_accept += 1
else
# Jump to the new place with probability "ratio"
u = rand()
if u < ratio
# Jump to the new place
p = p_new
logprob = logprob_new
n_accept += 1
else
# Stay where we are
end
end
Equivalent to
if ratio > rand():
accept!(chain, p)
end
chain, n_accept/n_steps
end;
[52]:
nothing
[ ]:
Simple
2 7
Julia 1.9.3 | Idle
Saving completed
Mode: Command
Ln 1, Col 8
Notes-from-class.ipynb


https://symmetry.pi.local/user/dlang/lab/workspaces/auto-w/tree/home/dlang/FittingAModel2024/Notes-from-class.ipynb
File Edit View Run Kernel Tabs Settings Help
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perlmutter99-jul
MCMC-filled-in.
Notes-from-clas
p99-data.txt
Notes-from-clas
Code
Julia 1.9.3
[ ]:
[54]:
function mcmc(logprob_func, propose_func, initial_p, n_steps)
p = initial_p
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for i in 1:n_steps
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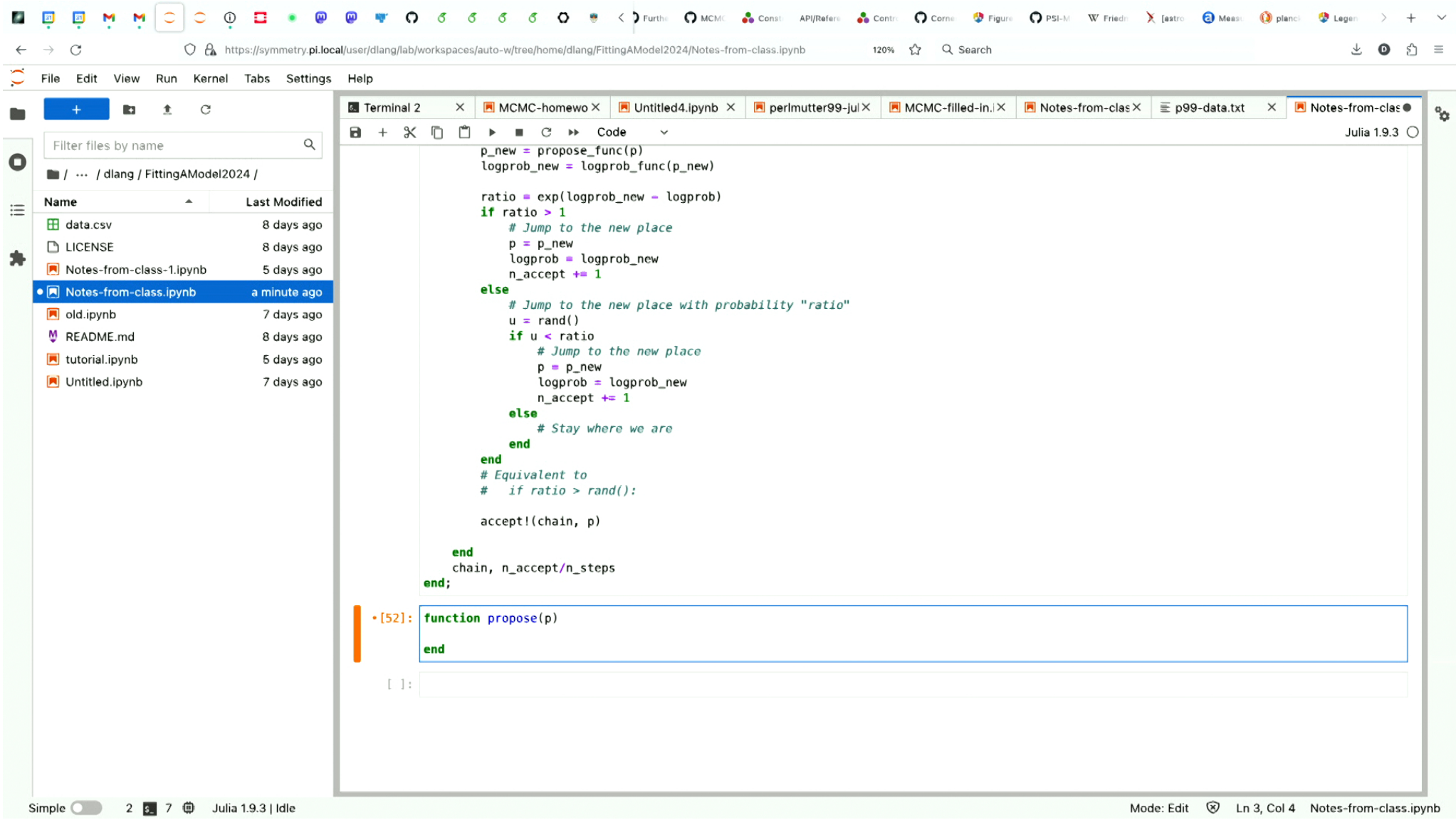
u = rand()
if u < ratio
# Jump to the new place
p = p_new
logprob = logprob_new
n_accept += 1
else
# Stay where we are
end
end
Equivalent to
if ratio > rand():
accept!(chain, p)
end
chain, n_accept/n_steps
end;
[52]:
function propose(
[ ]:
Simple
2 7
Julia 1.9.3 | Idle
Mode: Edit
Ln 1, Col 18
Notes-from-class.ipynb


https://symmetry.pi.local/user/dlang/lab/workspaces/auto-w/tree/home/dlang/FittingAModel2024/Notes-from-class.ipynb
File Edit View Run Kernel Tabs Settings Help
Terminal 2
MCMC-homewo
Untitled4.ipynb
perlmutter99-jul
MCMC-filled-in.
Notes-from-clas
p99-data.txt
Notes-from-clas
Code
Julia 1.9.3
Filter files by name
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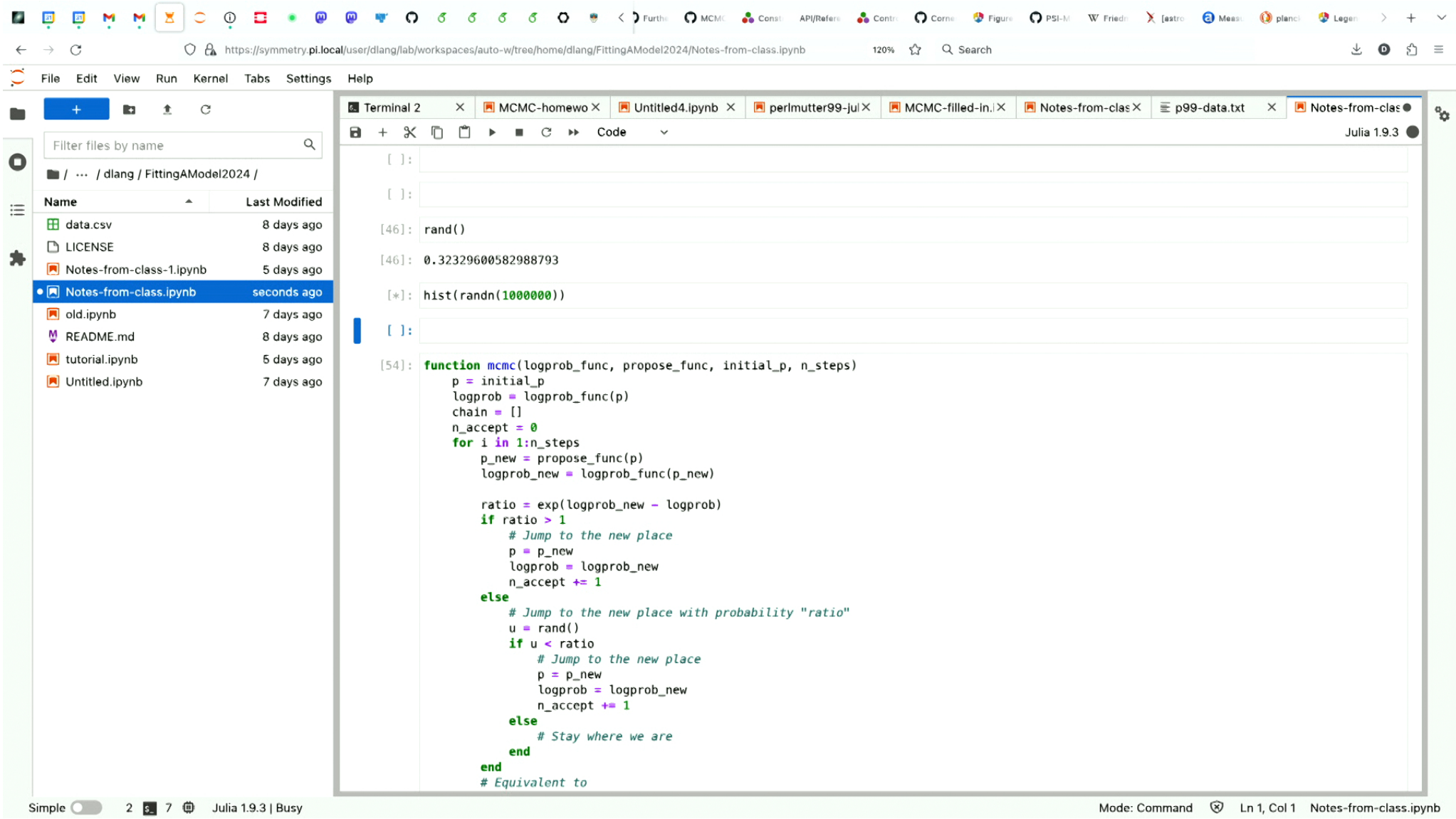
Name
Last Modified
data.csv 8 days ago
LICENSE 8 days ago
Notes-from-class-1.ipynb 5 days ago
Notes-from-class.ipynb a minute ago
old.ipynb 7 days ago
README.md 8 days ago
tutorial.ipynb 5 days ago
Untitled.ipynb 7 days ago
p_new = propose_func(p)
logprob_new = logprob_func(p_new)
ratio = exp(logprob_new - logprob)
if ratio > 1
# Jump to the new place
p = p_new
logprob = logprob_new
n_accept += 1
else
# Jump to the new place with probability "ratio"
u = rand()
if u < ratio
# Jump to the new place
p = p_new
logprob = logprob_new
n_accept += 1
else
# Stay where we are
end
end
Equivalent to
if ratio > rand():
accept!(chain, p)
end
chain, n_accept/n_steps
end;
[52]:
function propose(p)
end
[ ]:
Simple
2 7
Julia 1.9.3 | Idle
Mode: Edit
Ln 3, Col 4
Notes-from-class.ipynb


https://symmetry.pi.local/user/dlang/lab/workspaces/auto-w/tree/home/dlang/FittingAModel2024/Notes-from-class.ipynb
File Edit View Run Kernel Tabs Settings Help
Terminal 2
MCMC-homewo
Untitled4.ipynb
perlmutter99-jul
MCMC-filled-in.
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p99-data.txt
Notes-from-clas
Code
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Notes-from-class.ipynb seconds ago
old.ipynb 7 days ago
README.md 8 days ago
tutorial.ipynb 5 days ago
Untitled.ipynb 7 days ago
[46]: rand()
[46]: 0.32329600582988793
[*]: hist(randn(1000000))
[54]: function mcmc(logprob_func, propose_func, initial_p, n_steps)
p = initial_p
logprob = logprob_func(p)
chain = []
n_accept = 0
for i in 1:n_steps
p_new = propose_func(p)
logprob_new = logprob_func(p_new)
ratio = exp(logprob_new - logprob)
if ratio > 1
# Jump to the new place
p = p_new
logprob = logprob_new
n_accept += 1
else
# Jump to the new place with probability "ratio"
u = rand()
if u < ratio
# Jump to the new place
p = p_new
logprob = logprob_new
n_accept += 1
else
# Stay where we are
end
end
Equivalent to
Simple
Julia 1.9.3 | Busy
Mode: Command
Ln 1, Col 1
Notes-from-class.ipynb

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Terminal 2 | MCMC-homewo | Untitled4.ipynb | perlmutter99-jul | MCMC-filled-in. | Notes-from-clas | p99-data.txt | Notes-from-clas

Code Julia 1.9.3

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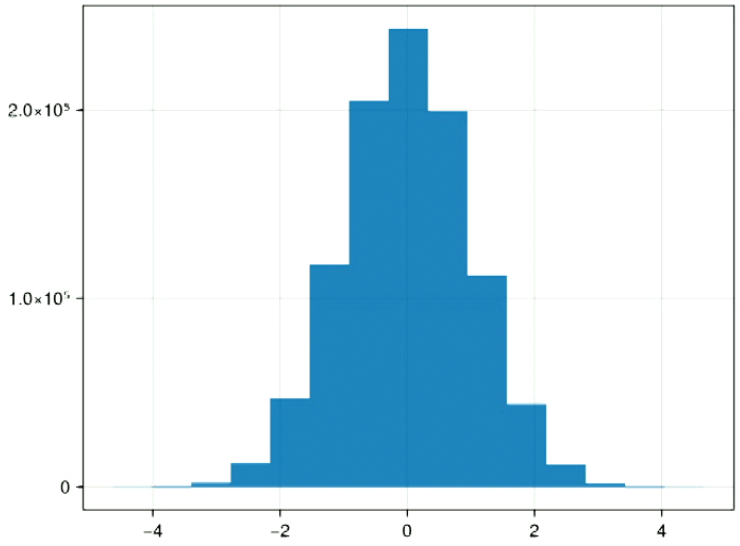
data.csv	8 days ago
LICENSE	8 days ago
Notes-from-class-1.ipynb	5 days ago
Notes-from-class.ipynb	seconds ago
old.ipynb	7 days ago
README.md	8 days ago
tutorial.ipynb	5 days ago
Untitled.ipynb	7 days ago

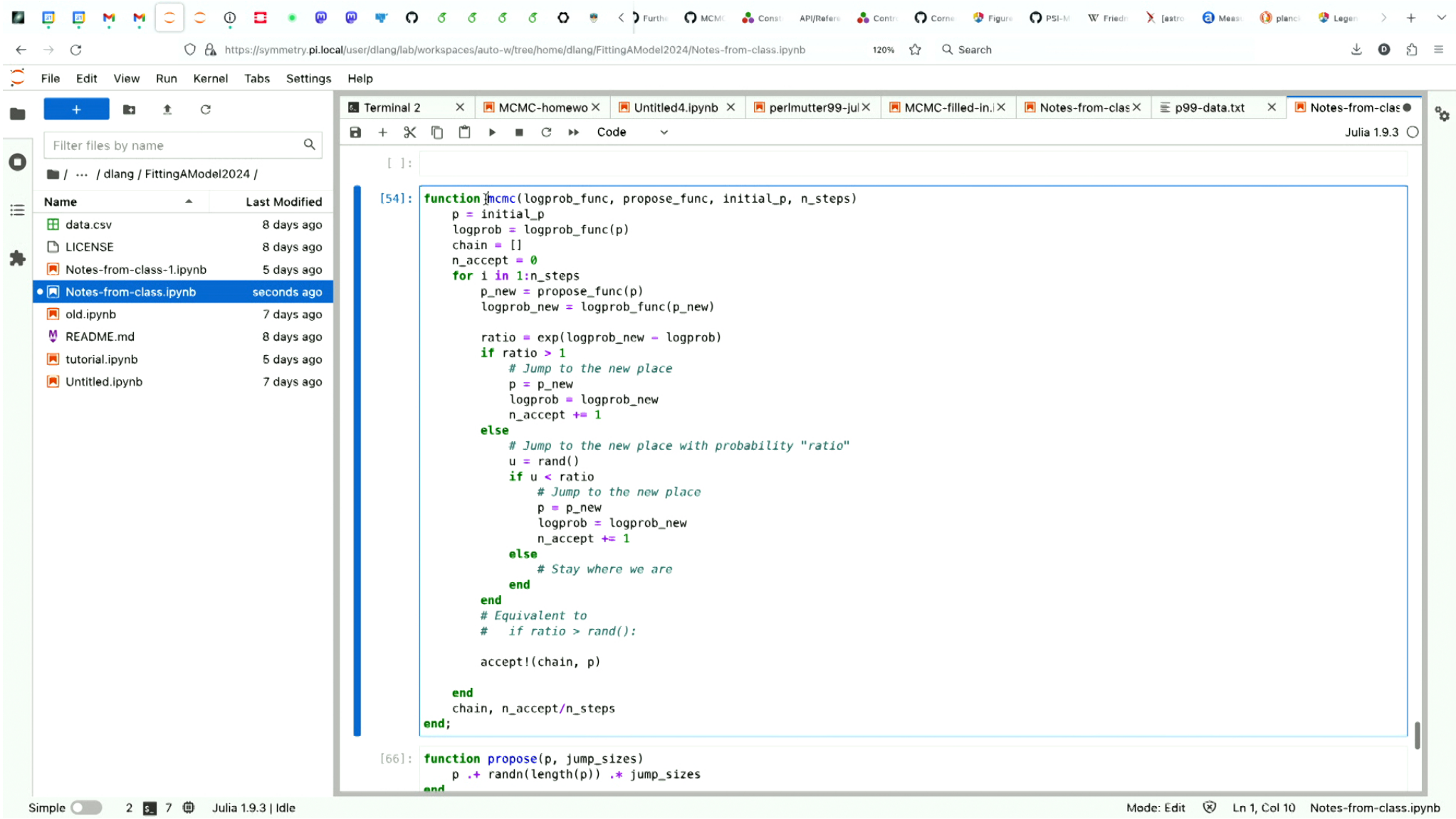
```
[ ]:
[ ]:
[46]: rand()
[46]: 0.32329600582988793
[61]: hist(randn(1000000))
```

[61]:




```
[ ]:
[54]: function mcmc(logprob_func, propose_func, initial_p, n_steps)
```

Simple 2 7 Julia 1.9.3 | Idle Mode: Command Ln 1, Col 1 Notes-from-class.ipynb


https://symmetry.pi.local/user/dlang/lab/workspaces/auto-w/tree/home/dlang/FittingAModel2024/Notes-from-class.ipynb
File Edit View Run Kernel Tabs Settings Help
Terminal 2
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Notes-from-clas
Code
Julia 1.9.3
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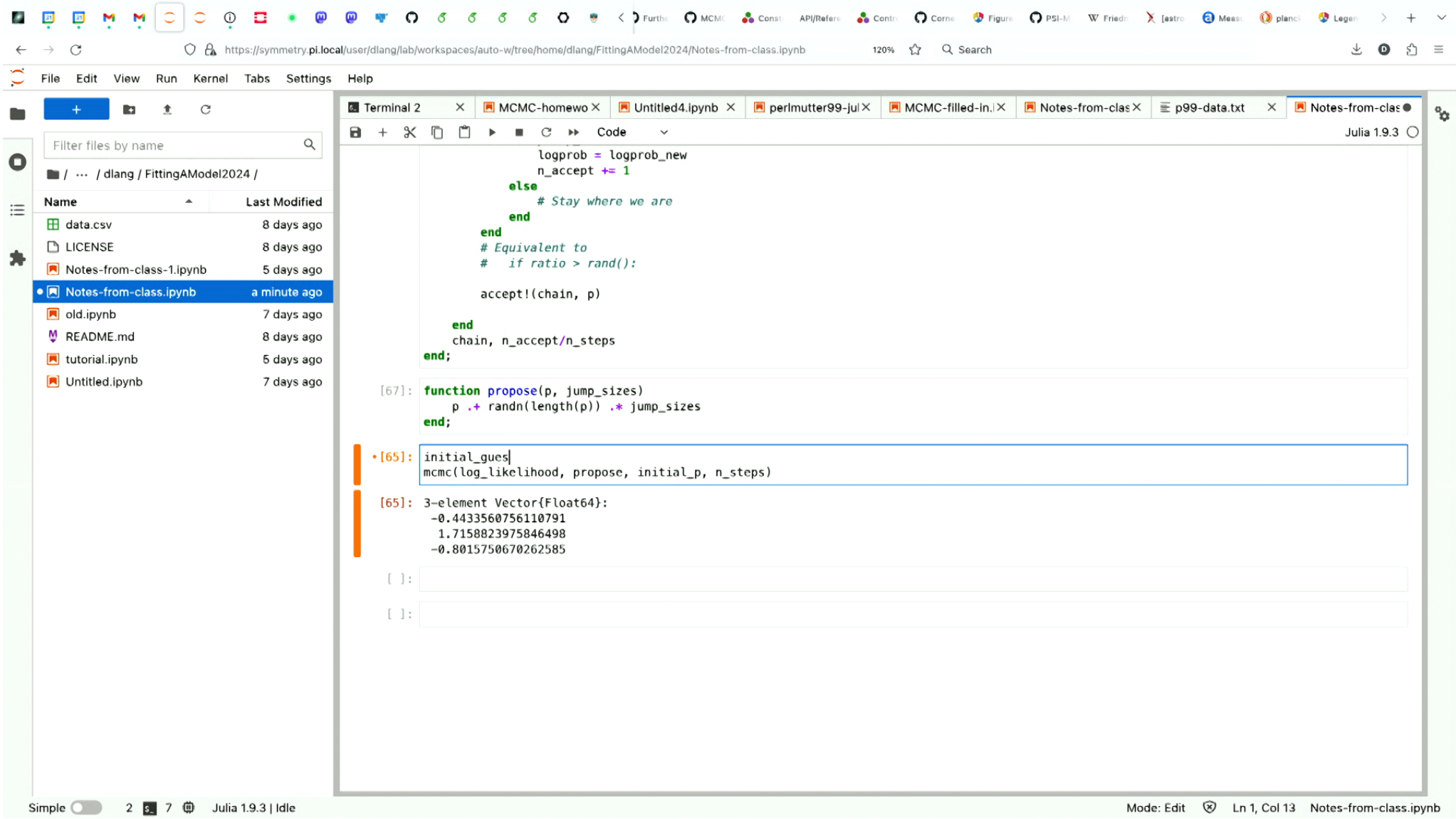
README.md 8 days ago
tutorial.ipynb 5 days ago
Untitled.ipynb 7 days ago
[ ]:
[54]:
function mcmc(logprob_func, propose_func, initial_p, n_steps)
p = initial_p
logprob = logprob_func(p)
chain = []
n_accept = 0
for i in 1:n_steps
p_new = propose_func(p)
logprob_new = logprob_func(p_new)
ratio = exp(logprob_new - logprob)
if ratio > 1
# Jump to the new place
p = p_new
logprob = logprob_new
n_accept += 1
else
# Jump to the new place with probability "ratio"
u = rand()
if u < ratio
# Jump to the new place
p = p_new
logprob = logprob_new
n_accept += 1
else
# Stay where we are
end
end
Equivalent to
if ratio > rand():
accept!(chain, p)
end
chain, n_accept/n_steps
end;
[66]:
function propose(p, jump_sizes)
p .+ randn(length(p)) .* jump_sizes
end
Simple
2 7
Julia 1.9.3 | Idle
Mode: Edit
Ln 1, Col 10
Notes-from-class.ipynb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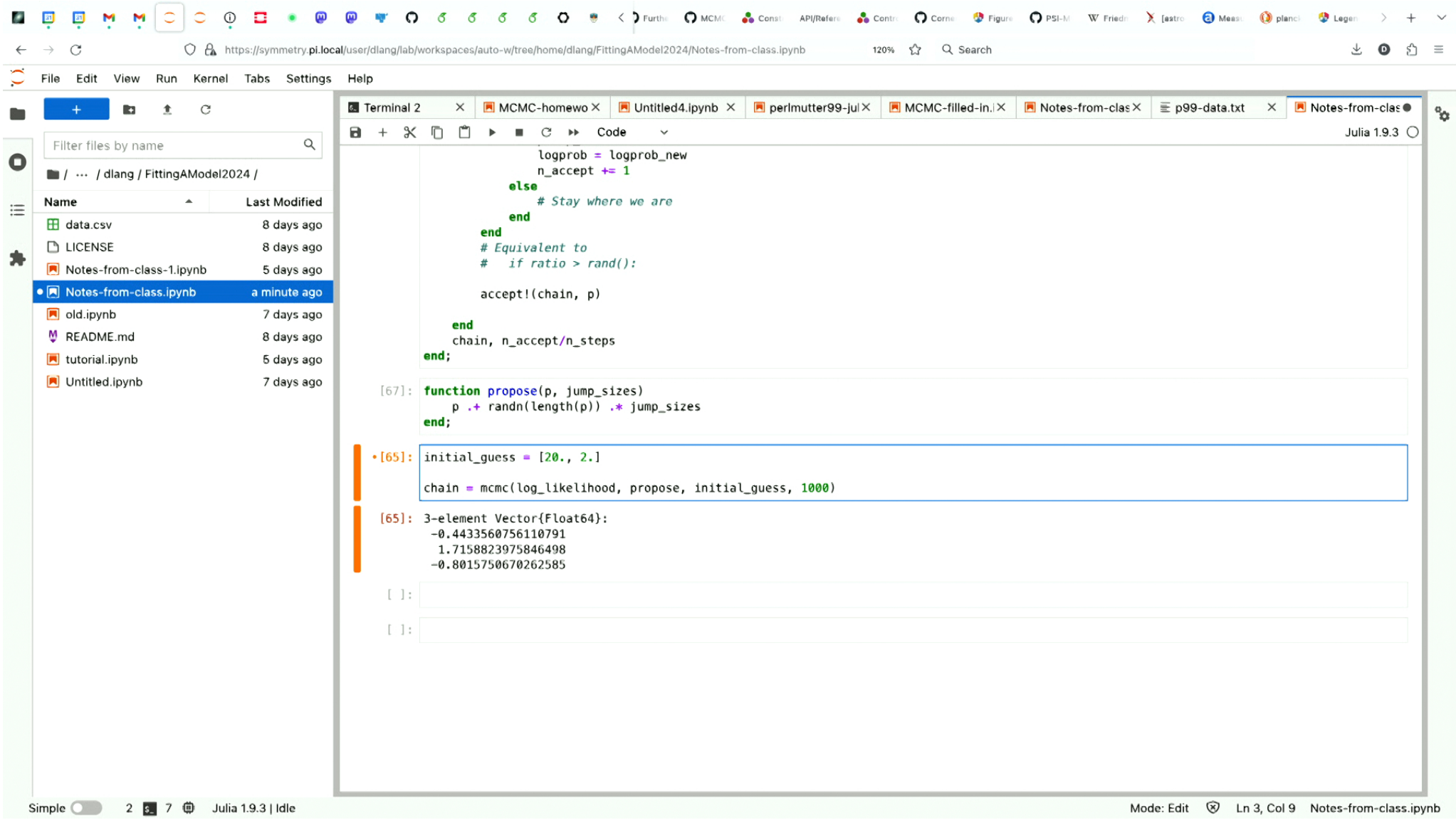
p99-data.txt
Notes-from-clas
Code
Julia 1.9.3
logprob = logprob_new
n_accept += 1
else
# Stay where we are
end
end
Equivalent to
if ratio > rand():
accept!(chain, p)
end
chain, n_accept/n_steps
end;
[67]:
function propose(p, jump_sizes)
p .+ randn(length(p)) .* jump_sizes
end;
[65]:
initial_gues
mcmc(log_likelihood, propose, initial_p, n_steps)
[65]:
3-element Vector{Float64}:
-0.4433560756110791
1.7158823975846498
-0.8015750670262585
[ ]:
[ ]:
Simple
2 7
Julia 1.9.3 | Idle
Mode: Edit
Ln 1, Col 13
Notes-from-class.ipynb


https://symmetry.pi.local/user/dlang/lab/workspaces/auto-w/tree/home/dlang/FittingAModel2024/Notes-from-class.ipynb
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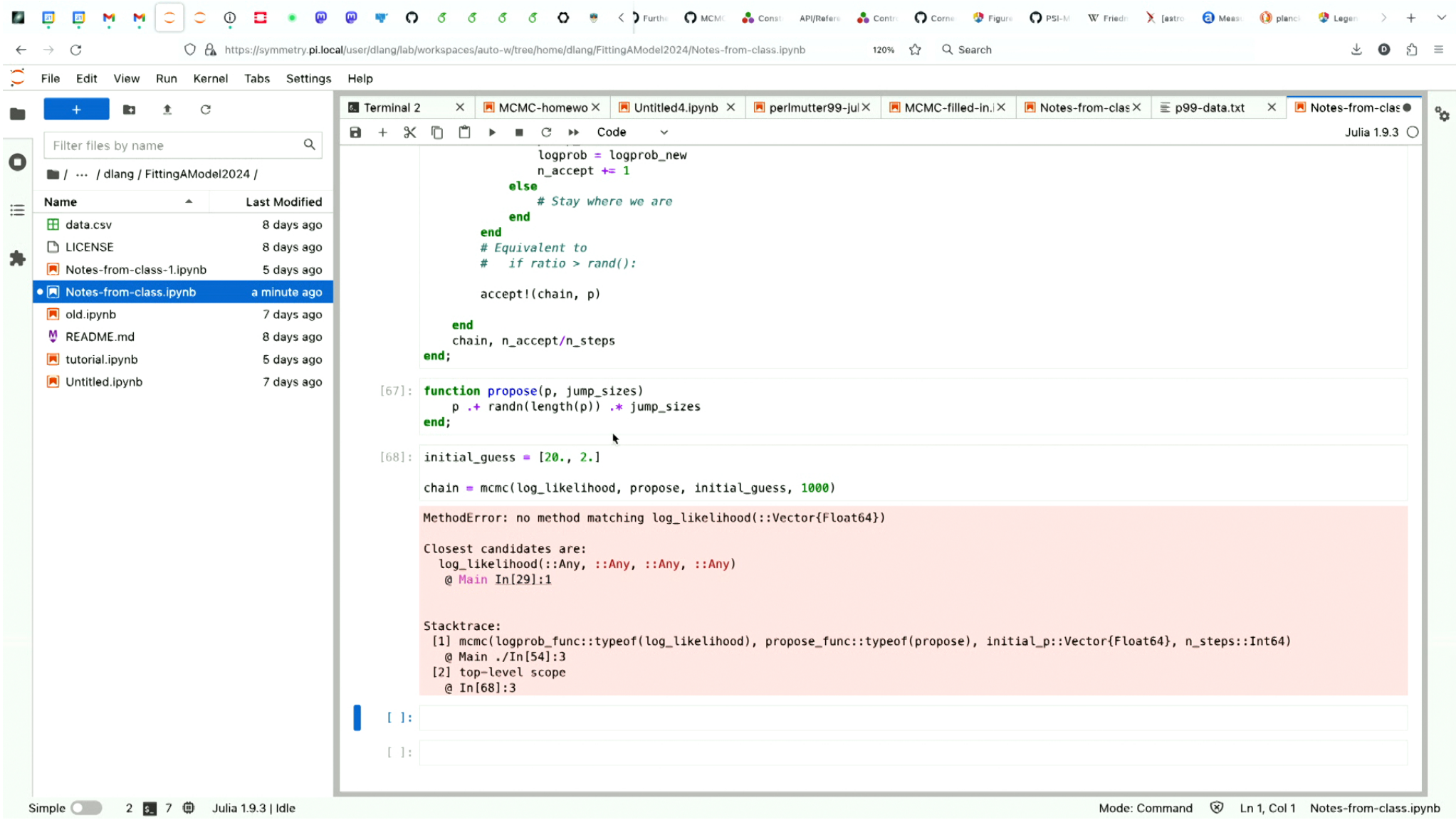
tutorial.ipynb 5 days ago
Untitled.ipynb 7 days ago
logprob = logprob_new
n_accept += 1
else
# Stay where we are
end
end
Equivalent to
if ratio > rand():
accept!(chain, p)
end
chain, n_accept/n_steps
end;
[67]:
function propose(p, jump_sizes)
p .+ randn(length(p)) .* jump_sizes
end;
[65]:
initial_guess = [20., 2.]
chain = mcmc(log_likelihood, propose, initial_guess, 1000)
[65]:
3-element Vector{Float64}:
-0.4433560756110791
1.7158823975846498
-0.8015750670262585
[ ]:
[ ]:
Simple
2 7
Julia 1.9.3 | Idle
Mode: Edit
Ln 3, Col 9
Notes-from-class.ipynb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Terminal 2
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Code
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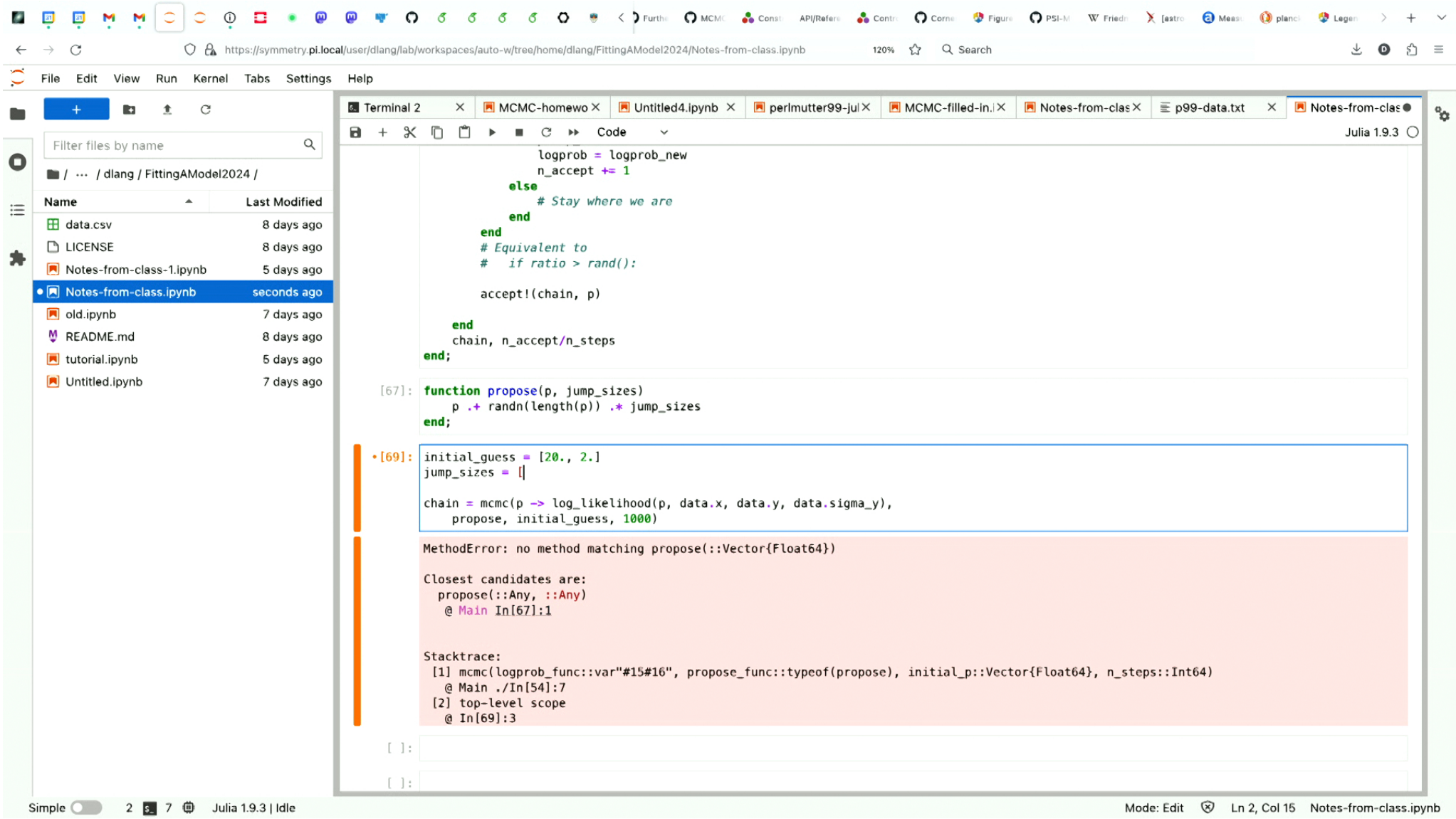
tutorial.ipynb 5 days ago
Untitled.ipynb 7 days ago
logprob = logprob_new
n_accept += 1
else
# Stay where we are
end
end
Equivalent to
if ratio > rand():
accept!(chain, p)
end
chain, n_accept/n_steps
end;
[67]:
function propose(p, jump_sizes)
p .+ randn(length(p)) .* jump_sizes
end;
[68]:
initial_guess = [20., 2.]
chain = mcmc(log_likelihood, propose, initial_guess, 1000)
MethodError: no method matching log_likelihood(::Vector{Float64})
Closest candidates are:
log_likelihood(::Any, ::Any, ::Any, ::Any)
@ Main In[29]:1
Stacktrace:
[1] mcmc(logprob_func::typeof(log_likelihood), propose_func::typeof(propose), initial_p::Vector{Float64}, n_steps::Int64)
@ Main ./In[54]:3
[2] top-level scope
@ In[68]:3
[ ]:
[ ]:
Simple
2 7
Julia 1.9.3 | Idle
Mode: Command
Ln 1, Col 1
Notes-from-class.ipynb


https://symmetry.pi.local/user/dlang/lab/workspaces/auto-w/tree/home/dlang/FittingAModel2024/Notes-from-class.ipynb
File Edit View Run Kernel Tabs Settings Help
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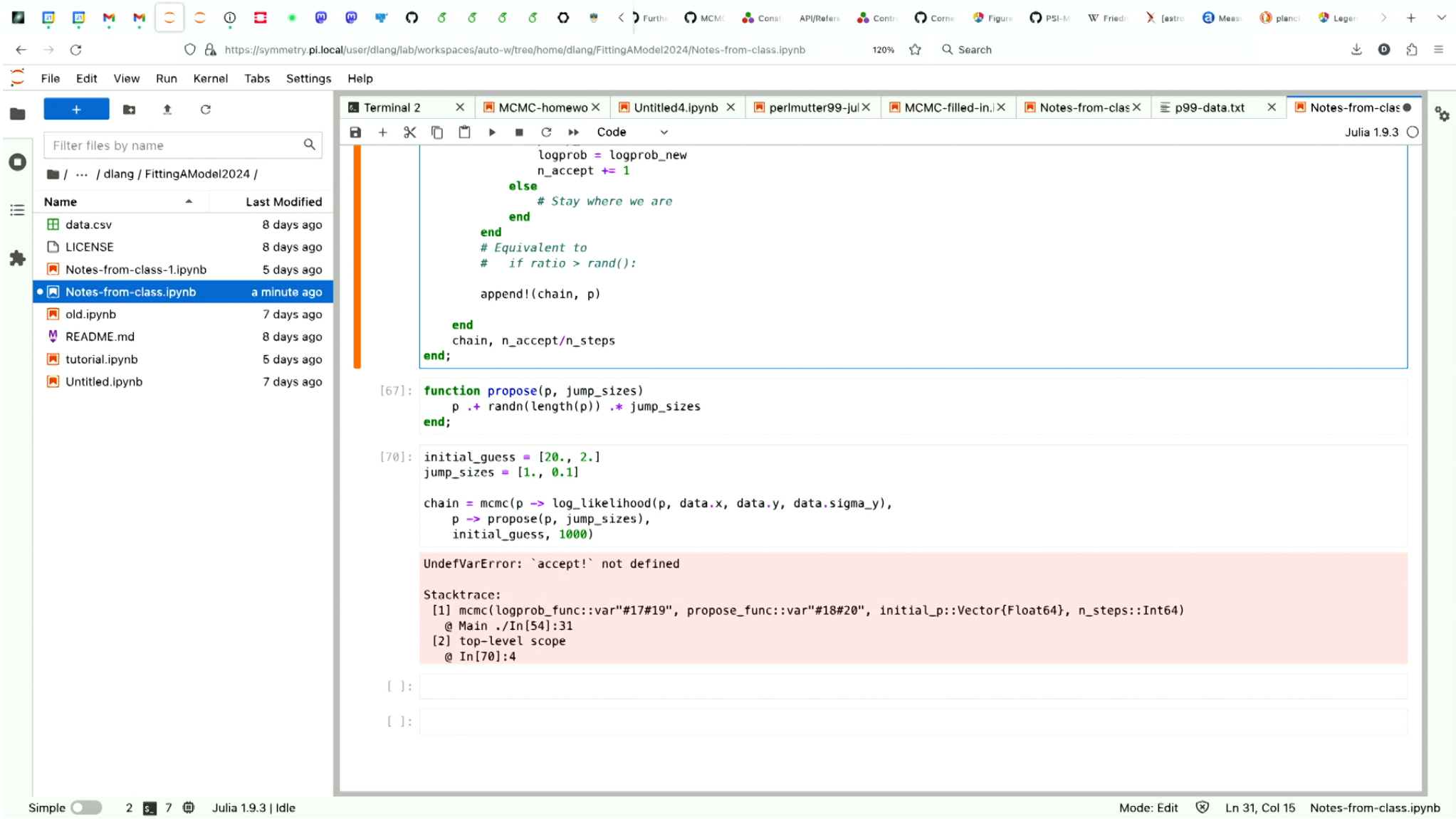
Code
Julia 1.9.3
logprob = logprob_new
n_accept += 1
else
# Stay where we are
end
end
Equivalent to
if ratio > rand():
accept!(chain, p)
end
chain, n_accept/n_steps
end;
[67]:
function propose(p, jump_sizes)
p .+ randn(length(p)) .* jump_sizes
end;
•[69]:
initial_guess = [20., 2.]
jump_sizes = [
chain = mcmc(p -> log_likelihood(p, data.x, data.y, data.sigma_y),
propose, initial_guess, 1000)
MethodError: no method matching propose(::Vector{Float64})
Closest candidates are:
propose(::Any, ::Any)
@ Main In[67]:1
Stacktrace:
[1] mcmc(logprob_func::var"#15#16", propose_func::typeof(propose), initial_p::Vector{Float64}, n_steps::Int64)
@ Main ./In[54]:7
[2] top-level scope
@ In[69]:3
[ ]:
[ ]:
Simple
2 7
Julia 1.9.3 | Idle
Mode: Edit
Ln 2, Col 15
Notes-from-class.ipynb


https://symmetry.pi.local/user/dlang/lab/workspaces/auto-w/tree/home/dlang/FittingAModel2024/Notes-from-class.ipynb
File Edit View Run Kernel Tabs Settings Help
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Code
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Untitled.ipynb 7 days ago
logprob = logprob_new
n_accept += 1
else
# Stay where we are
end
end
Equivalent to
if ratio > rand():
append!(chain, p)
end
chain, n_accept/n_steps
end;
[67]:
function propose(p, jump_sizes)
p .+ randn(length(p)) .* jump_sizes
end;
[70]:
initial_guess = [20., 2.]
jump_sizes = [1., 0.1]
chain = mcmc(p -> log_likelihood(p, data.x, data.y, data.sigma_y),
p -> propose(p, jump_sizes),
initial_guess, 1000)
UndefVarError: `accept!` not defined
Stacktrace:
[1] mcmc(logprob_func::var"#17#19", propose_func::var"#18#20", initial_p::Vector{Float64}, n_steps::Int64)
@ Main ./In[54]:31
[2] top-level scope
@ In[70]:4
[ ]:
[ ]:
Simple
2 7
Julia 1.9.3 | Idle
Mode: Edit
Ln 31, Col 15
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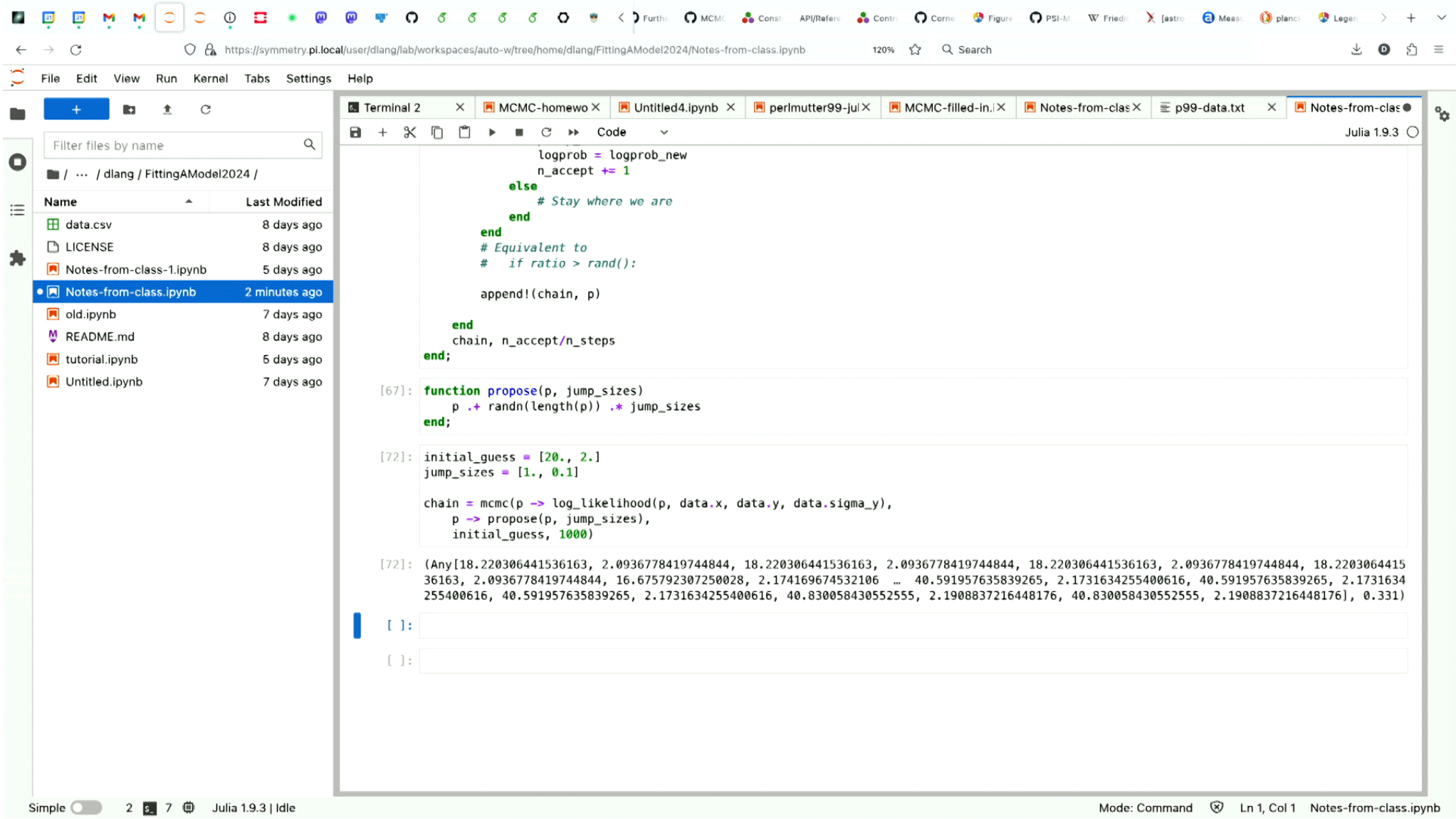
https://symmetry.pi.local/user/dlang/lab/workspaces/auto-w/tree/home/dlang/FittingAModel2024/Notes-from-class.ipynb
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Code
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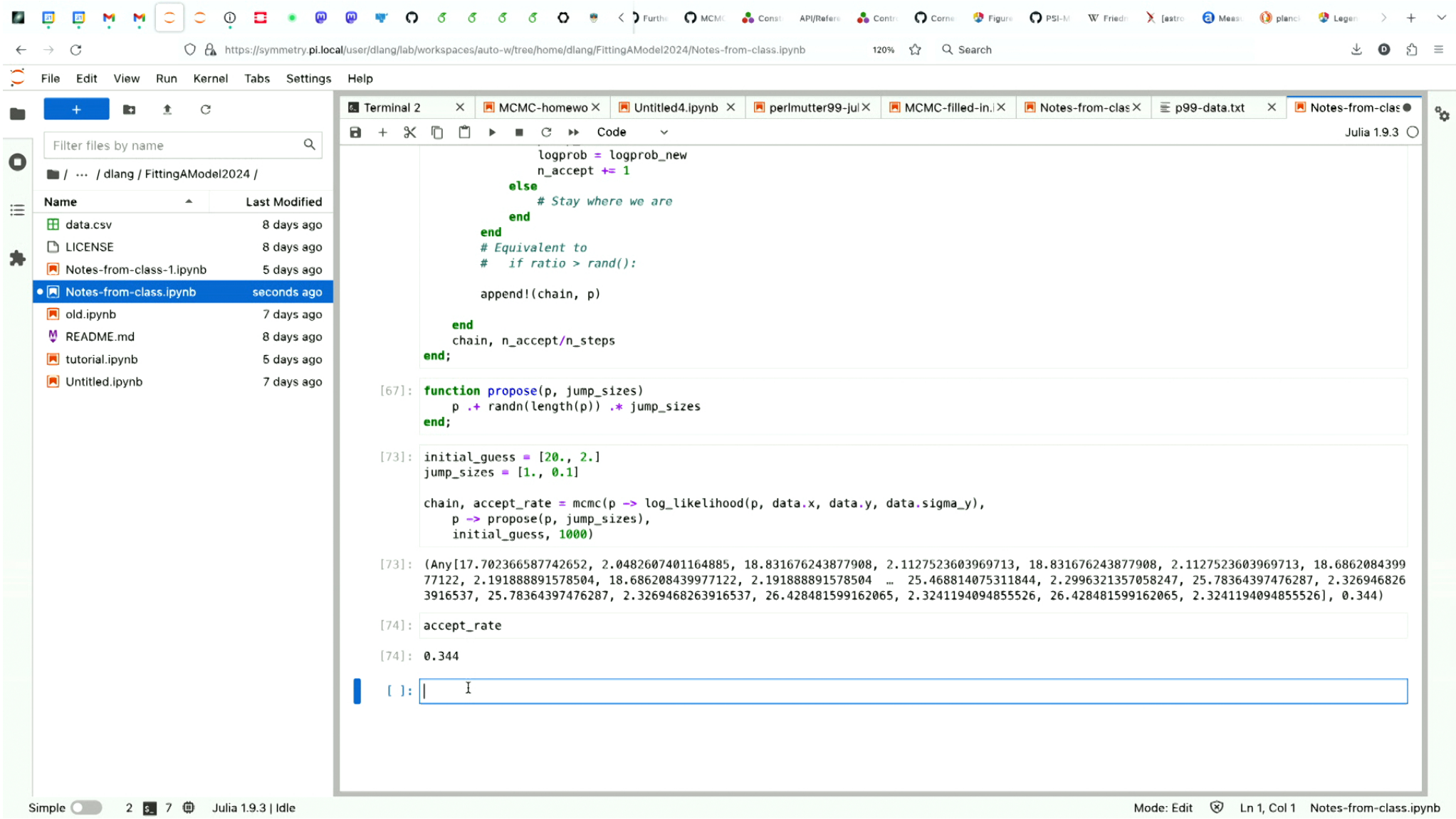
logprob = logprob_new
n_accept += 1
else
# Stay where we are
end
end
Equivalent to
if ratio > rand():
append!(chain, p)
end
chain, n_accept/n_steps
end;
[67]:
function propose(p, jump_sizes)
p .+ randn(length(p)) .* jump_sizes
end;
[72]:
initial_guess = [20., 2.]
jump_sizes = [1., 0.1]
chain = mcmc(p -> log_likelihood(p, data.x, data.y, data.sigma_y),
p -> propose(p, jump_sizes),
initial_guess, 1000)
[72]:
(Any[18.220306441536163, 2.0936778419744844, 18.220306441536163, 2.0936778419744844, 18.220306441536163, 2.0936778419744844, 18.220306441536163, 2.0936778419744844, 16.675792307250028, 2.174169674532106 … 40.591957635839265, 2.1731634255400616, 40.591957635839265, 2.1731634255400616, 40.591957635839265, 2.1731634255400616, 40.830058430552555, 2.1908837216448176, 40.830058430552555, 2.1908837216448176], 0.331)
[ ]:
[ ]:
Simple
2 7
Julia 1.9.3 | Idle
Mode: Command
Ln 1, Col 1
Notes-from-class.ipynb


File Edit View Run Kernel Tabs Settings Help
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Code
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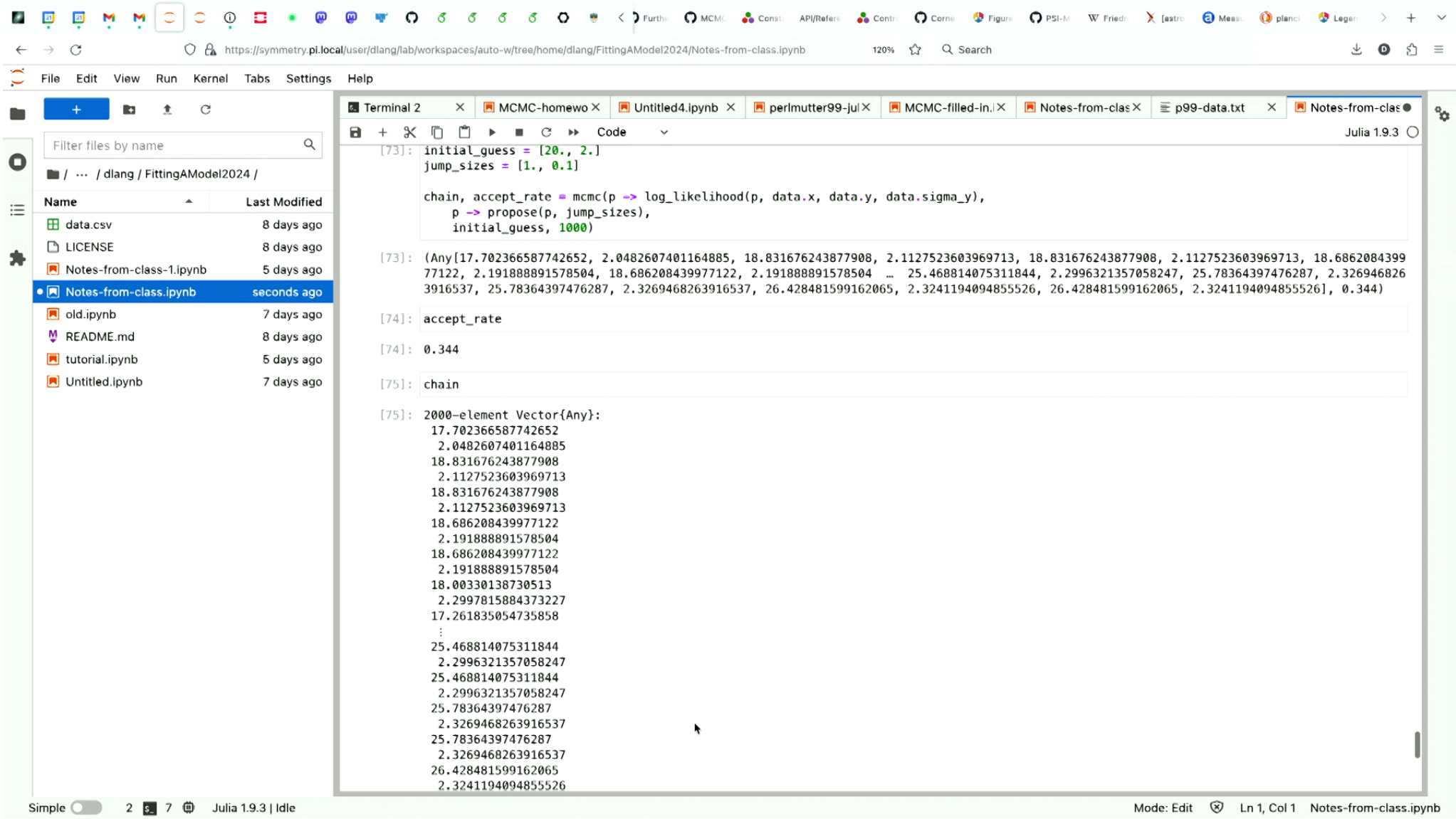
old.ipynb 7 days ago
README.md 8 days ago
tutorial.ipynb 5 days ago
Untitled.ipynb 7 days ago
logprob = logprob_new
n_accept += 1
else
# Stay where we are
end
end
Equivalent to
if ratio > rand():
append!(chain, p)
end
chain, n_accept/n_steps
end;
[67]:
function propose(p, jump_sizes)
p .+ randn(length(p)) .* jump_sizes
end;
[73]:
initial_guess = [20., 2.]
jump_sizes = [1., 0.1]
chain, accept_rate = mcmc(p -> log_likelihood(p, data.x, data.y, data.sigma_y),
p -> propose(p, jump_sizes),
initial_guess, 1000)
[73]:
(Any[17.702366587742652, 2.0482607401164885, 18.831676243877908, 2.1127523603969713, 18.831676243877908, 2.1127523603969713, 18.686208439977122, 2.191888891578504, 18.686208439977122, 2.191888891578504 … 25.468814075311844, 2.2996321357058247, 25.78364397476287, 2.3269468263916537, 25.78364397476287, 2.3269468263916537, 26.428481599162065, 2.3241194094855526, 26.428481599162065, 2.3241194094855526], 0.344)
[74]:
accept_rate
[74]:
0.344
[ ]:
Simple
2 7
Julia 1.9.3 | Idle
Mode: Edit
Ln 1, Col 1
Notes-from-class.ipynb


https://symmetry.pi.local/user/dlang/lab/workspaces/auto-w/tree/home/dlang/FittingAModel2024/Notes-from-class.ipynb
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Code
Julia 1.9.3
[73]: initial_guess = [20., 2.]
jump_sizes = [1., 0.1]
chain, accept_rate = mcmc(p -> log_likelihood(p, data.x, data.y, data.sigma_y),
p -> propose(p, jump_sizes),
initial_guess, 1000)
[73]: (Any[17.702366587742652, 2.0482607401164885, 18.831676243877908, 2.1127523603969713, 18.831676243877908, 2.1127523603969713, 18.686208439977122, 2.191888891578504, 18.686208439977122, 2.191888891578504 … 25.468814075311844, 2.2996321357058247, 25.78364397476287, 2.3269468263916537, 25.78364397476287, 2.3269468263916537, 26.428481599162065, 2.3241194094855526, 26.428481599162065, 2.3241194094855526], 0.344)
[74]: accept_rate
[74]: 0.344
[75]: chain
[75]: 2000-element Vector{Any}:
17.702366587742652
2.0482607401164885
18.831676243877908
2.1127523603969713
18.831676243877908
2.1127523603969713
18.686208439977122
2.191888891578504
18.686208439977122
2.191888891578504
18.00330138730513
2.2997815884373227
17.261835054735858
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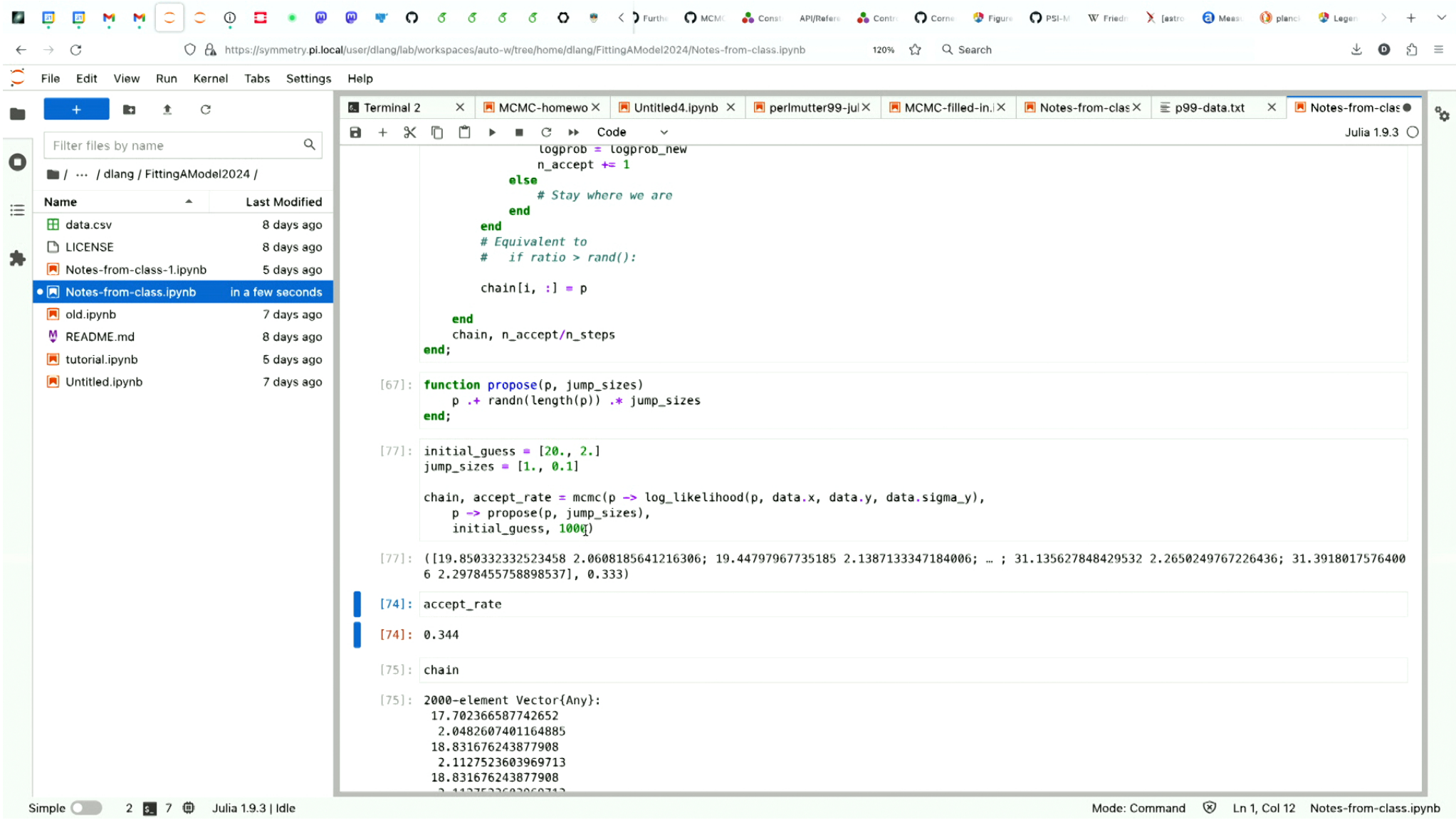
2.2996321357058247
25.468814075311844
2.2996321357058247
25.78364397476287
2.3269468263916537
25.78364397476287
2.3269468263916537
26.428481599162065
2.3241194094855526
Simple
2 7
Julia 1.9.3 | Idle
Mode: Edit
Ln 1, Col 1
Notes-from-class.ipynb


https://symmetry.pi.local/user/dlang/lab/workspaces/auto-w/tree/home/dlang/FittingAModel2024/Notes-from-class.ipynb
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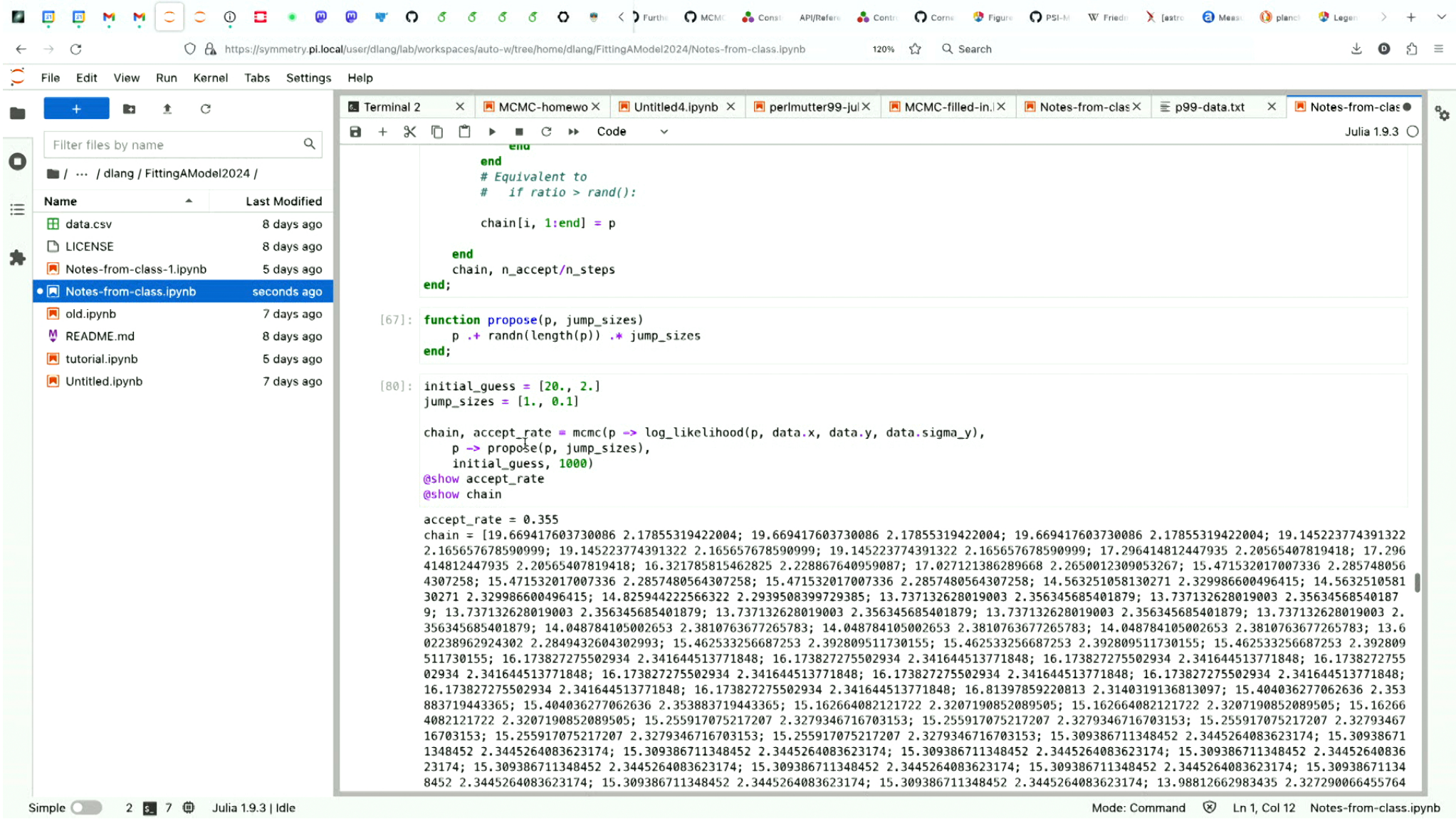
Terminal 2
MCMC-homewo
Untitled4.ipynb
perlmutter99-jul
MCMC-filled-in.
Notes-from-clas
p99-data.txt
Notes-from-clas
Code
Julia 1.9.3
logprob = logprob_new
n_accept += 1
else
# Stay where we are
end
end
Equivalent to
if ratio > rand():
chain[i, :] = p
end
chain, n_accept/n_steps
end;
[67]:
function propose(p, jump_sizes)
p .+ randn(length(p)) .* jump_sizes
end;
[77]:
initial_guess = [20., 2.]
jump_sizes = [1., 0.1]
chain, accept_rate = mcmc(p -> log_likelihood(p, data.x, data.y, data.sigma_y),
p -> propose(p, jump_sizes),
initial_guess, 1000)
[77]:
([19.850332332523458 2.0608185641216306; 19.44797967735185 2.1387133347184006; … ; 31.135627848429532 2.2650249767226436; 31.3918017576400
6 2.2978455758898537], 0.333)
[74]:
accept_rate
[74]:
0.344
[75]:
chain
[75]:
2000-element Vector{Any}:
17.702366587742652
2.0482607401164885
18.831676243877908
2.1127523603969713
18.831676243877908
Simple 2 7 Julia 1.9.3 | Idle
Mode: Command Ln 1, Col 12 Notes-from-class.ipynb


https://symmetry.pi.local/user/dlang/lab/workspaces/auto-w/tree/home/dlang/FittingAModel2024/Notes-from-class.ipynb
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perlmutter99-jul
MCMC-filled-in.
Notes-from-clas
p99-data.txt
Notes-from-clas
Code
Julia 1.9.3
end
end
Equivalent to
if ratio > rand():
chain[i, 1:end] = p
end
chain, n_accept/n_steps
end;
[67]:
function propose(p, jump_sizes)
p .+ randn(length(p)) .* jump_sizes
end;
[80]:
initial_guess = [20., 2.]
jump_sizes = [1., 0.1]
chain, accept_rate = mcmc(p -> log_likelihood(p, data.x, data.y, data.sigma_y),
p -> propose(p, jump_sizes),
initial_guess, 1000)
@show accept_rate
@show chain
accept_rate = 0.355
chain = [19.669417603730086 2.17855319422004; 19.669417603730086 2.17855319422004; 19.669417603730086 2.17855319422004; 19.145223774391322
2.165657678590999; 19.145223774391322 2.165657678590999; 19.145223774391322 2.165657678590999; 17.296414812447935 2.20565407819418; 17.296
414812447935 2.20565407819418; 16.321785815462825 2.228867640959087; 17.027121386289668 2.2650012309053267; 15.471532017007336 2.285748056
4307258; 15.471532017007336 2.2857480564307258; 15.471532017007336 2.2857480564307258; 14.563251058130271 2.329986600496415; 14.5632510581
30271 2.329986600496415; 14.825944222566322 2.2939508399729385; 13.737132628019003 2.356345685401879; 13.737132628019003 2.35634568540187
9; 13.737132628019003 2.356345685401879; 13.737132628019003 2.356345685401879; 13.737132628019003 2.356345685401879; 13.737132628019003 2.
356345685401879; 14.048784105002653 2.3810763677265783; 14.048784105002653 2.3810763677265783; 14.048784105002653 2.3810763677265783; 13.6
02238962924302 2.2849432604302993; 15.462533256687253 2.392809511730155; 15.462533256687253 2.392809511730155; 15.462533256687253 2.392809
511730155; 16.173827275502934 2.341644513771848; 16.173827275502934 2.341644513771848; 16.173827275502934 2.341644513771848; 16.1738272755
02934 2.341644513771848; 16.173827275502934 2.341644513771848; 16.173827275502934 2.341644513771848; 16.173827275502934 2.341644513771848;
16.173827275502934 2.341644513771848; 16.173827275502934 2.341644513771848; 16.81397859220813 2.3140319136813097; 15.404036277062636 2.353
883719443365; 15.404036277062636 2.353883719443365; 15.162664082121722 2.3207190852089505; 15.162664082121722 2.3207190852089505; 15.16266
4082121722 2.3207190852089505; 15.255917075217207 2.3279346716703153; 15.255917075217207 2.3279346716703153; 15.255917075217207 2.32793467
16703153; 15.255917075217207 2.3279346716703153; 15.255917075217207 2.3279346716703153; 15.309386711348452 2.3445264083623174; 15.30938671
1348452 2.3445264083623174; 15.309386711348452 2.3445264083623174; 15.309386711348452 2.3445264083623174; 15.309386711348452 2.34452640836
23174; 15.309386711348452 2.3445264083623174; 15.309386711348452 2.3445264083623174; 15.309386711348452 2.3445264083623174; 15.30938671134
8452 2.3445264083623174; 15.309386711348452 2.3445264083623174; 15.309386711348452 2.3445264083623174; 13.98812662983435 2.327290066455764
Simple 2 7 Julia 1.9.3 | Idle
Mode: Command Ln 1, Col 12 Notes-from-class.ipynb

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Code Julia 1.9.3

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tutorial.ipynb	5 days ago
Untitled.ipynb	7 days ago

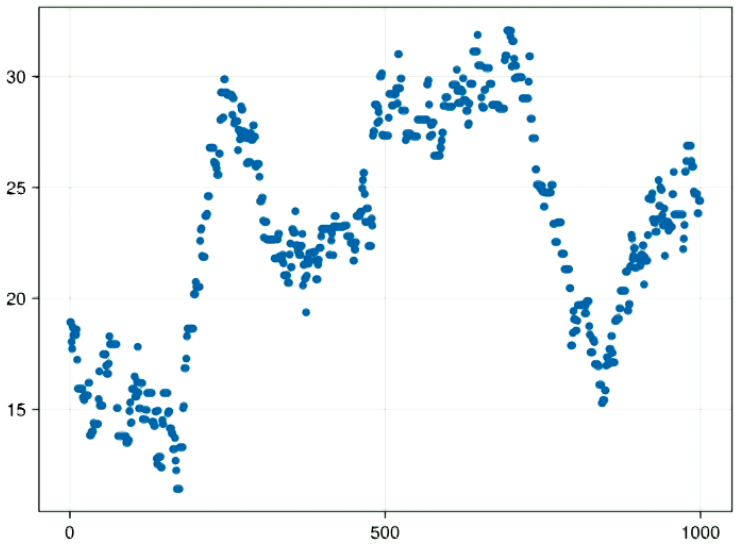
```
    initial_guess, 1000)
@show accept_rate
@show size(chain)
```

```
accept_rate = 0.365
size(chain) = (1000, 2)
```

[81]:
```
(1000, 2)
```

[85]:
```
plot(chain[:,1])
```

[85]:



[ ]:

Simple 2 7 Julia 1.9.3 | Idle Mode: Command Ln 1, Col 1 Notes-from-class.ipynb

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Code Julia 1.9.3

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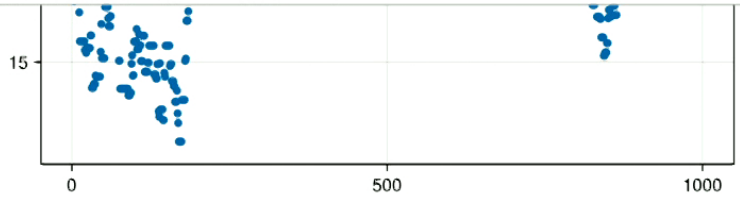
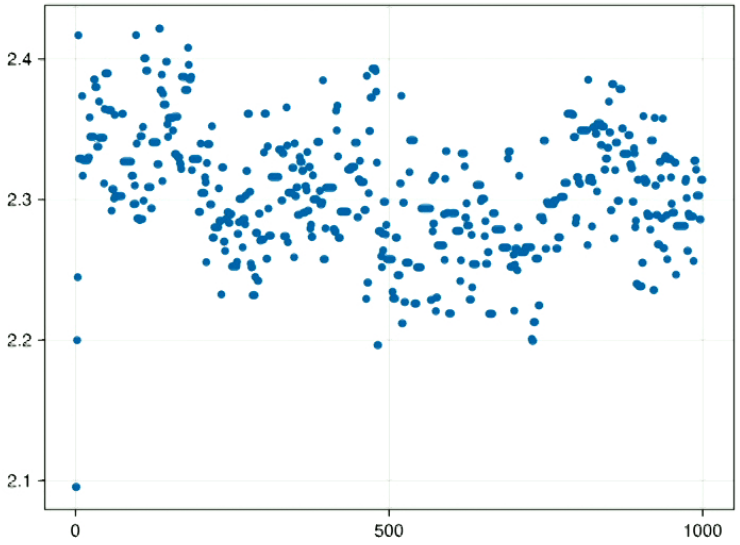


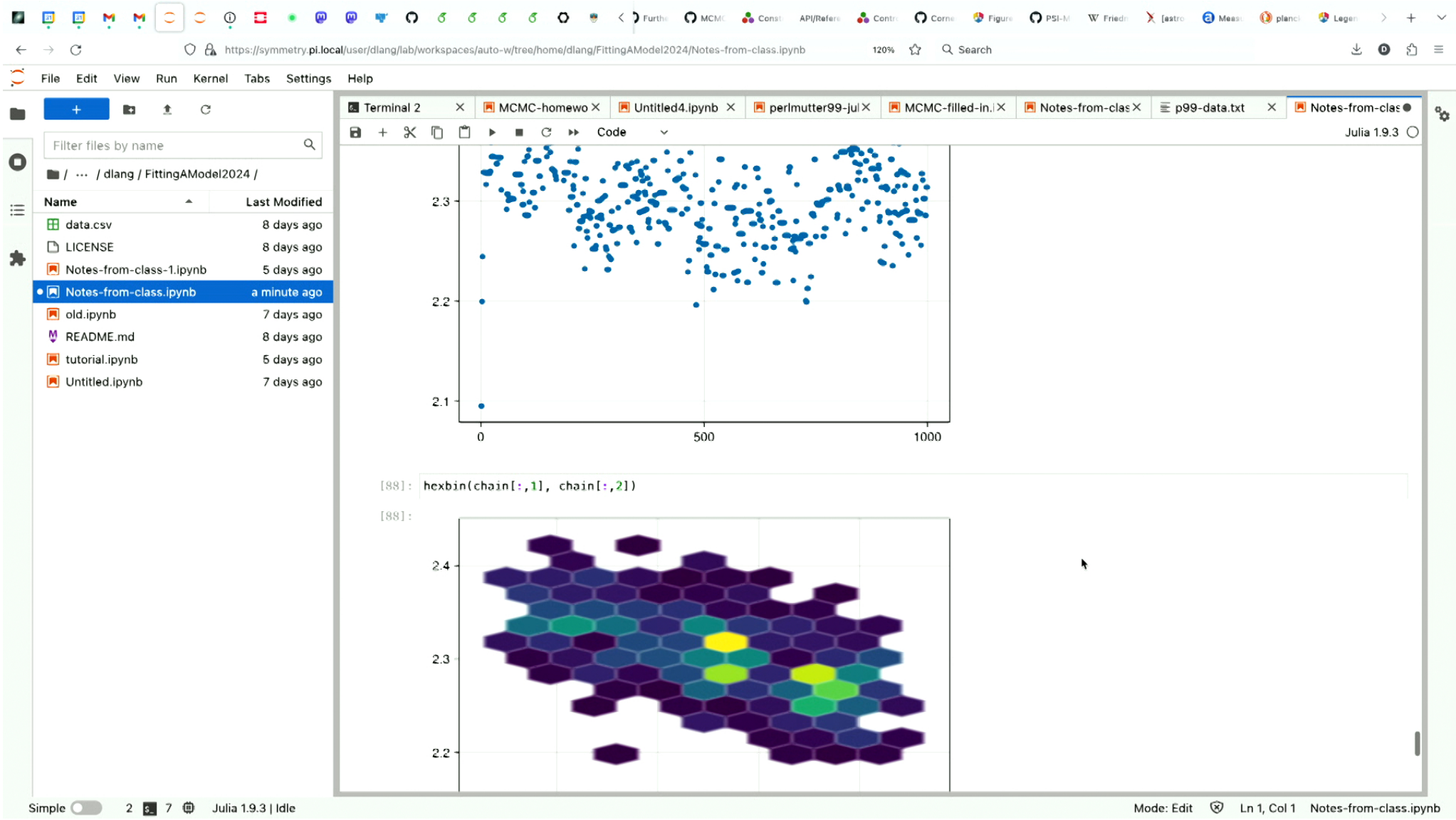
[87]:
```
plot(chain[:,2])
```

[87]:



[ ]:

Simple 2 7 Julia 1.9.3 | Idle Mode: Command Ln 1, Col 1 Notes-from-class.ipynb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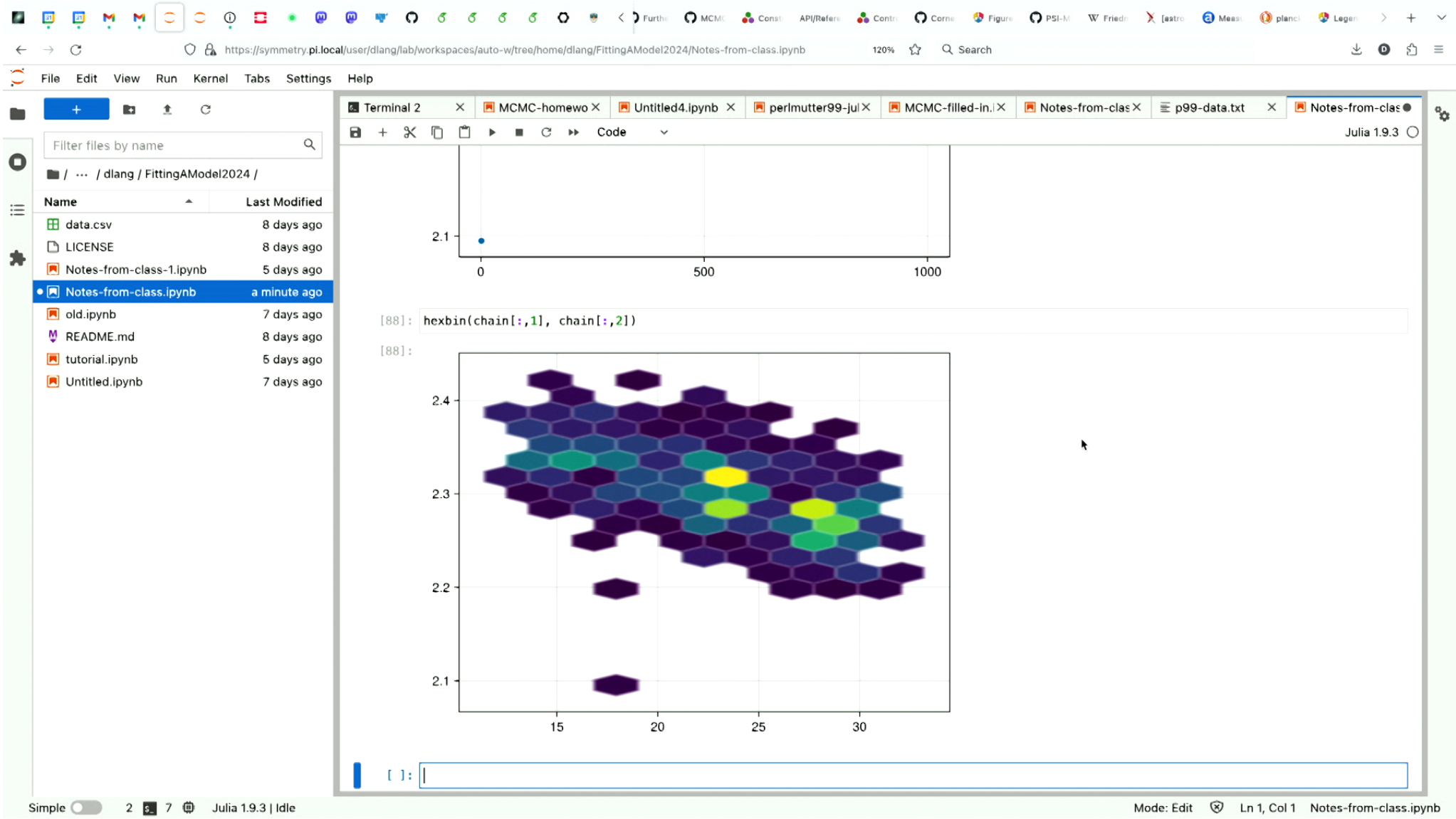
Untitled4.ipynb
perlmutter99-jul
MCMC-filled-in.
Notes-from-clas
p99-data.txt
Notes-from-clas
Code
Julia 1.9.3
2.3
2.2
2.1
0
500
1000
[88]:
hexbin(chain[:,1], chain[:,2])
[88]:
2.4
2.3
2.2
Simple
Julia 1.9.3 | Idle
Mode: Edit
Ln 1, Col 1
Notes-from-class.ipynb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old.ipynb 7 days ago
README.md 8 days ago
tutorial.ipynb 5 days ago
Untitled.ipynb 7 days ago
2.1
0
500
1000
[88]: hexbin(chain[:,1], chain[:,2])
[88]:
2.4
2.3
2.2
2.1
15
20
25
30
[ ]:
Simple
Julia 1.9.3 | Idle
Mode: Edit
Ln 1, Col 1
Notes-from-class.ipynb

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Code Julia 1.9.3

Filter files by name

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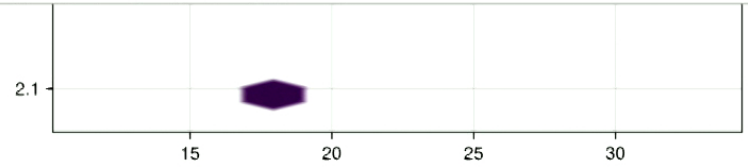
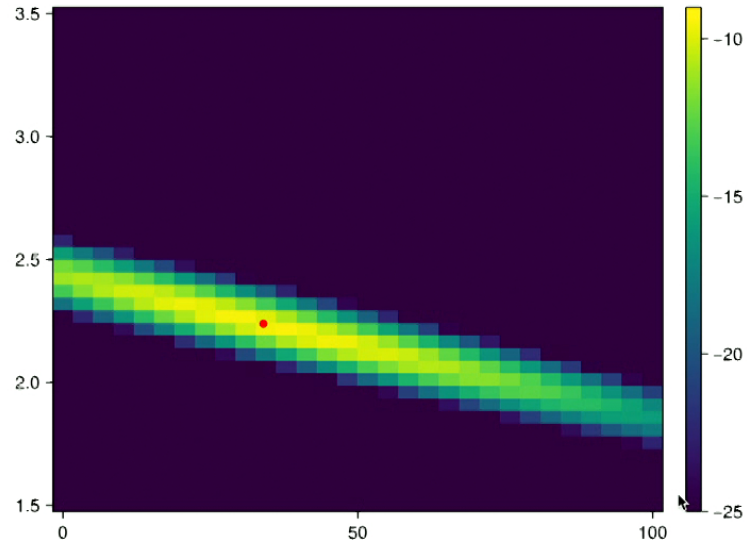


[89]:
```
fig, ax, hm = heatmap(b_grid, m_grid, ll_grid, colorrange=(-25, -9))
Colorbar(fig[:, end+1], hm)
scatter!(b_opt, m_opt, color=:red)
fig
```

[89]:



Simple 2 7 Julia 1.9.3 | Idle Mode: Edit Ln 1, Col 1 Notes-from-class.ipynb

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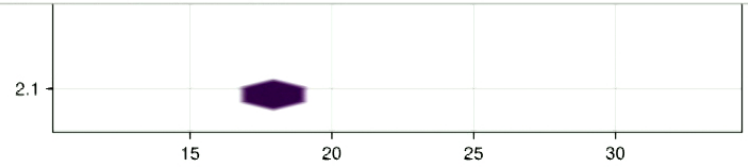
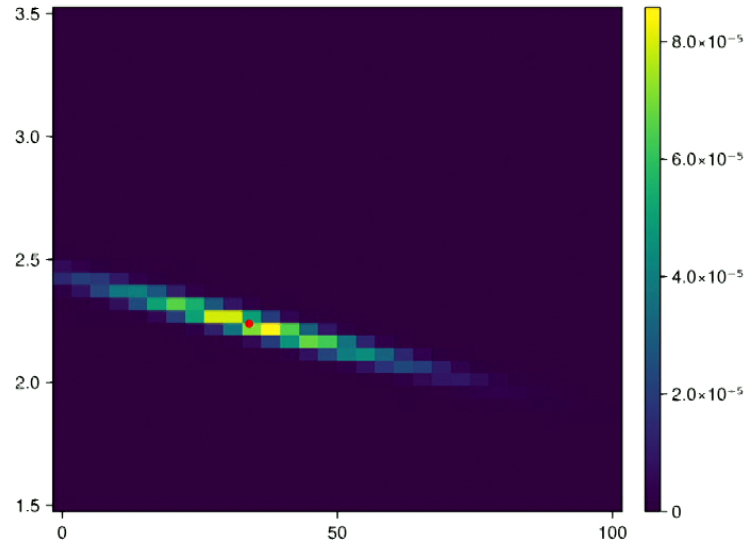


[90]:
```
fig, ax, hm = heatmap(b_grid, m_grid, exp.(ll_grid))
Colorbar(fig[:, end+1], hm)
scatter!(b_opt, m_opt, color=:red)
fig
```

[90]:



Simple 2 7 Julia 1.9.3 | Idle Mode: Command Ln 1, Col 1 Notes-from-class.ipynb

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Code Julia 1.9.3

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old.ipynb	7 days ago
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tutorial.ipynb	5 days ago
Untitled.ipynb	7 days ago

[67]:
```
function propose(p, jump_sizes)
    p .+ randn(length(p)) .* jump_sizes
end;
```

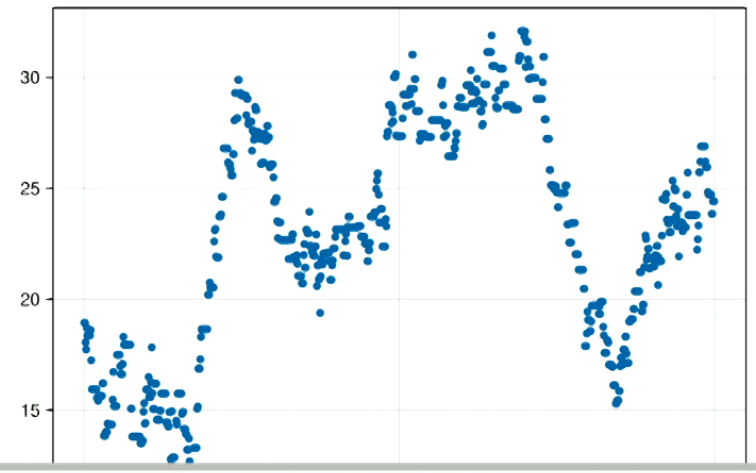
[91]:
```
initial_guess = [20., 2.]
jump_sizes = [1., 0.1]

chain, accept_rate = mcmc(p -> log_likelihood(p, data.x, data.y, data.sigma_y),
    p -> propose(p, jump_sizes),
    initial_guess, 10000)
@show accept_rate
@show size(chain)
```

```
accept_rate = 0.3442
size(chain) = (10000, 2)
```

[91]: (10000, 2)

[85]:
```
plot(chain[1:10:end,1])
```

[85]:



Simple 2 7 Julia 1.9.3 | Idle Mode: Edit Ln 1, Col 20 Notes-from-class.ipynb

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Terminal 2 | MCMC-homewo | Untitled4.ipynb | perlmutter99-jul | MCMC-filled-in. | Notes-from-clas | p99-data.txt | Notes-from-clas

Code Julia 1.9.3

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tutorial.ipynb	5 days ago
Untitled.ipynb	7 days ago

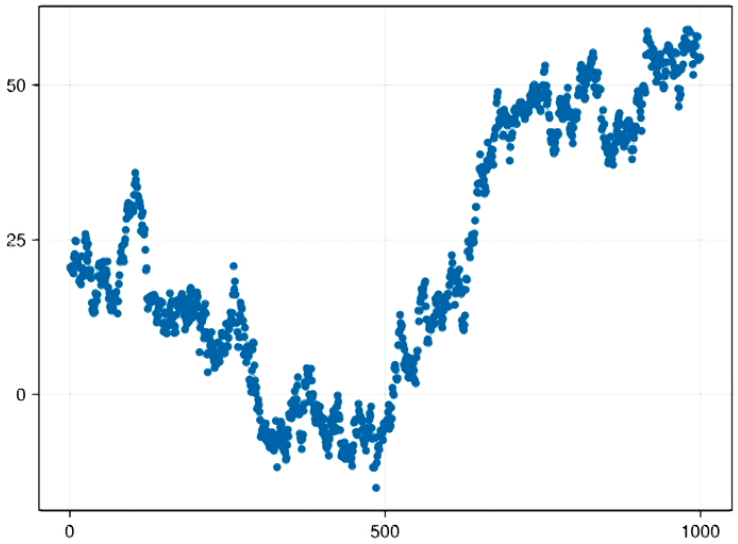
```
    initial_guess, 10000)
@show accept_rate
@show size(chain)
```

```
accept_rate = 0.3442
size(chain) = (10000, 2)
```

[91]: (10000, 2)

[92]:
```
plot(chain[1:10:end, 1])
```

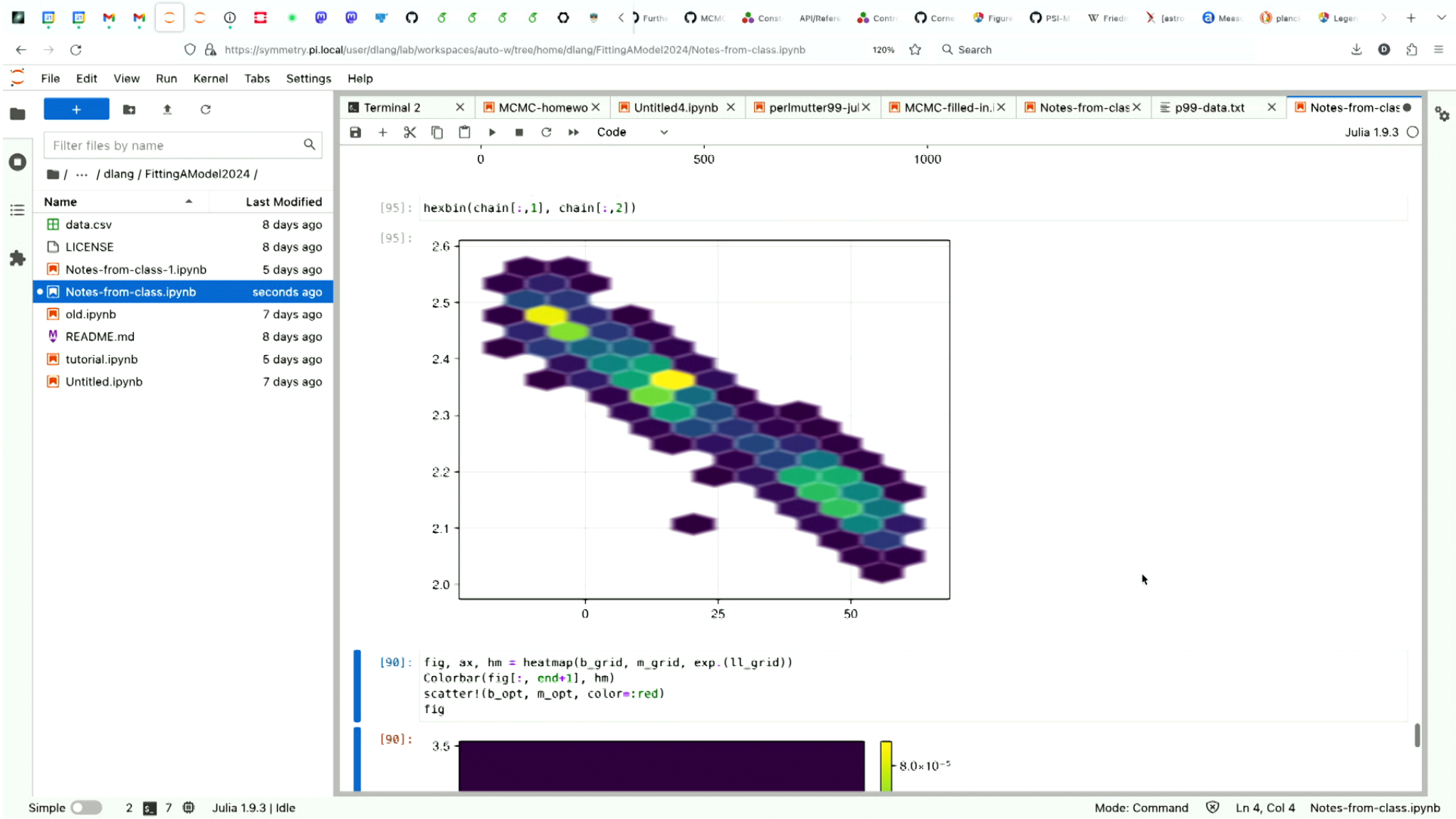
[92]:



[87]:
```
plot(chain[:,2])
```

[87]:

Simple 2 7 Julia 1.9.3 | Idle Mode: Command Ln 1, Col 22 Notes-from-class.ipynb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File Edit View Run Kernel Tabs Settings Help
Terminal 2
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Untitled4.ipynb
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Notes-from-clas
p99-data.txt
Notes-from-clas
Code
Julia 1.9.3
Filter files by name
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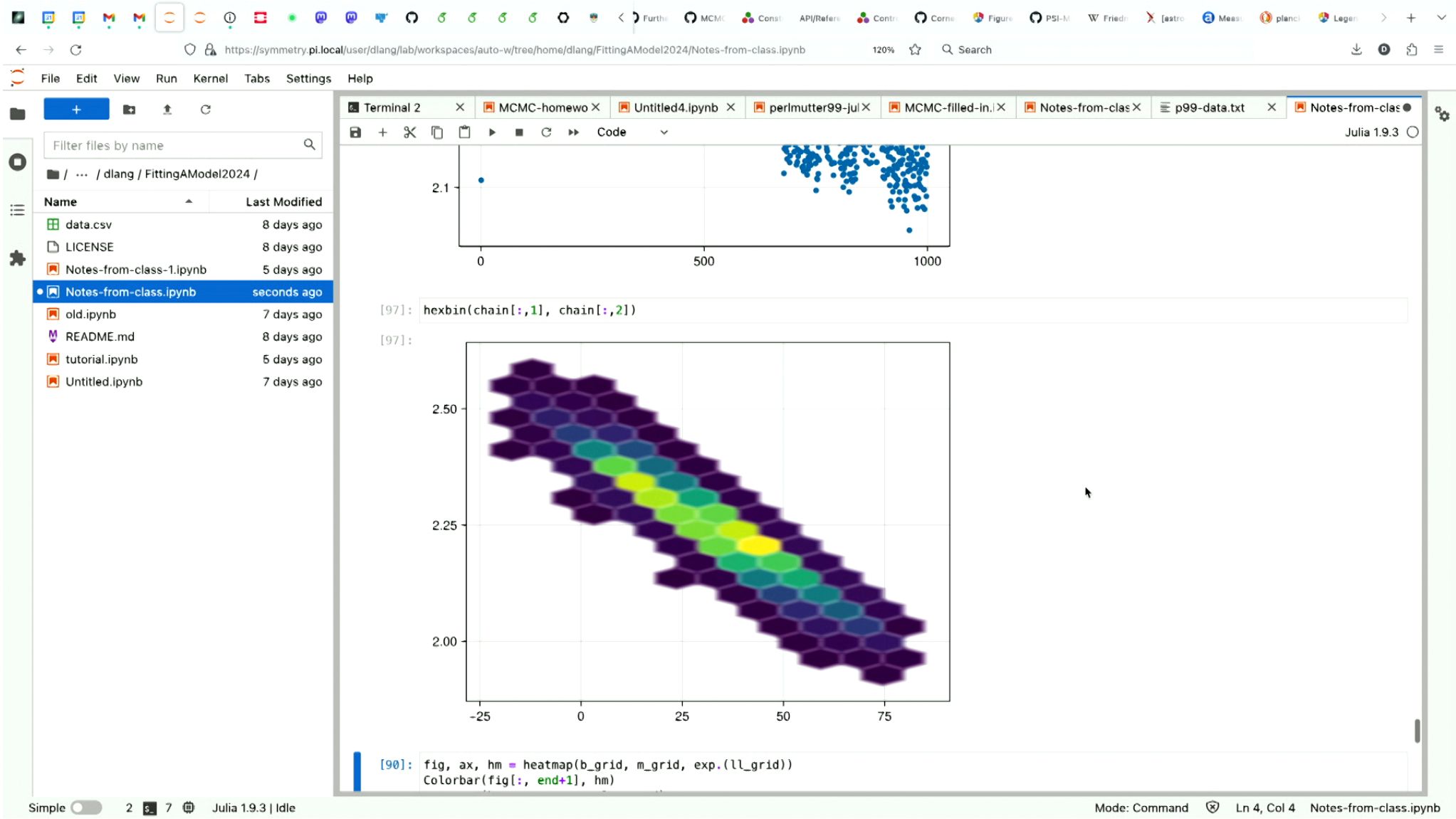
old.ipynb 7 days ago
README.md 8 days ago
tutorial.ipynb 5 days ago
Untitled.ipynb 7 days ago
0
500
1000
[95]: hexbin(chain[:,1], chain[:,2])
[95]:
2.6
2.5
2.4
2.3
2.2
2.1
2.0
0
25
50
[90]: fig, ax, hm = heatmap(b_grid, m_grid, exp.(ll_grid))
Colorbar(fig[:, end+1], hm)
scatter!(b_opt, m_opt, color=:red)
fig
[90]:
3.5
8.0×10⁻⁵
Simple
2 7
Julia 1.9.3 | Idle
Mode: Command
Ln 4, Col 4
Notes-from-class.ipynb


https://symmetry.pi.local/user/dlang/lab/workspaces/auto-w/tree/home/dlang/FittingAModel2024/Notes-from-class.ipynb
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Notes-from-clas
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old.ipynb 7 days ago
README.md 8 days ago
tutorial.ipynb 5 days ago
Untitled.ipynb 7 days ago
2.1
0
500
1000
[97]: hexbin(chain[:,1], chain[:,2])
[97]:
2.50
2.25
2.00
-25
0
25
50
75
[90]: fig, ax, hm = heatmap(b_grid, m_grid, exp.(ll_grid))
Colorbar(fig[:, end+1], hm)
Simple
Julia 1.9.3 | Idle
Mode: Command
Ln 4, Col 4
Notes-from-class.ipynb

https://symmetry.pi.local/user/dlang/lab/workspaces/auto-w/tree/home/dlang/FittingAModel2024/Notes-from-class.ipynb

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Code Julia 1.9.3

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Name	Last Modified
data.csv	8 days ago
LICENSE	8 days ago
Notes-from-class-1.ipynb	5 days ago
Notes-from-class.ipynb	2 minutes ago
old.ipynb	7 days ago
README.md	8 days ago
tutorial.ipynb	5 days ago
Untitled.ipynb	7 days ago

```
        chain[1, 1:end] = p

    end
    chain, n_accept/n_steps
end;
```

[67]:
```
function propose(p, jump_sizes)
    p .+ randn(length(p)) .* jump_sizes
end;
```

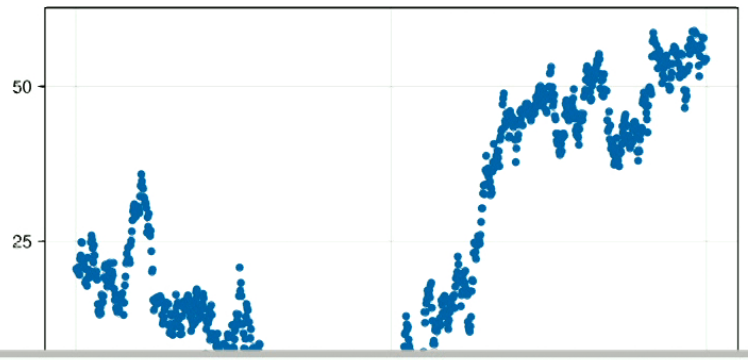
[96]:
```
initial_guess = [20., 2.]
jump_sizes = [1., 0.1]

chain, accept_rate = mcmc(p -> log_likelihood(p, data.x, data.y, data.sigma_y),
    p -> propose(p, jump_sizes),
    initial_guess, 100000)
@show accept_rate
@show size(chain)
```

```
accept_rate = 0.34177
size(chain) = (100000, 2)
```

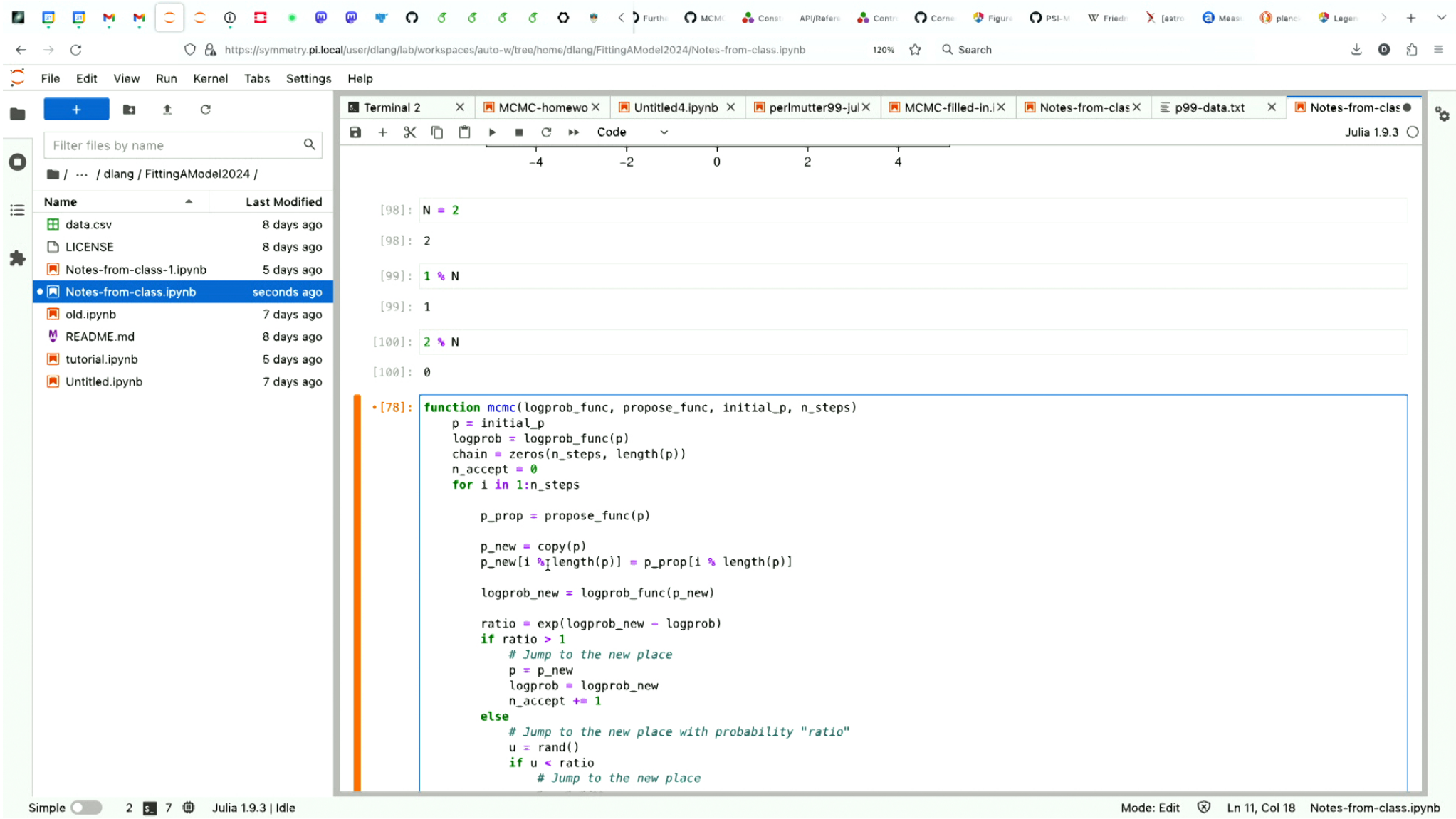
[96]:
```
(100000, 2)
```

[92]:
```
plot(chain[1:10:end, 1])
```

[92]:



Simple 2 7 Julia 1.9.3 | Idle Saving started Mode: Edit Ln 3, Col 1 Notes-from-class.ipynb


https://symmetry.pi.local/user/dlang/lab/workspaces/auto-w/tree/home/dlang/FittingAModel2024/Notes-from-class.ipynb
File Edit View Run Kernel Tabs Settings Help
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Name
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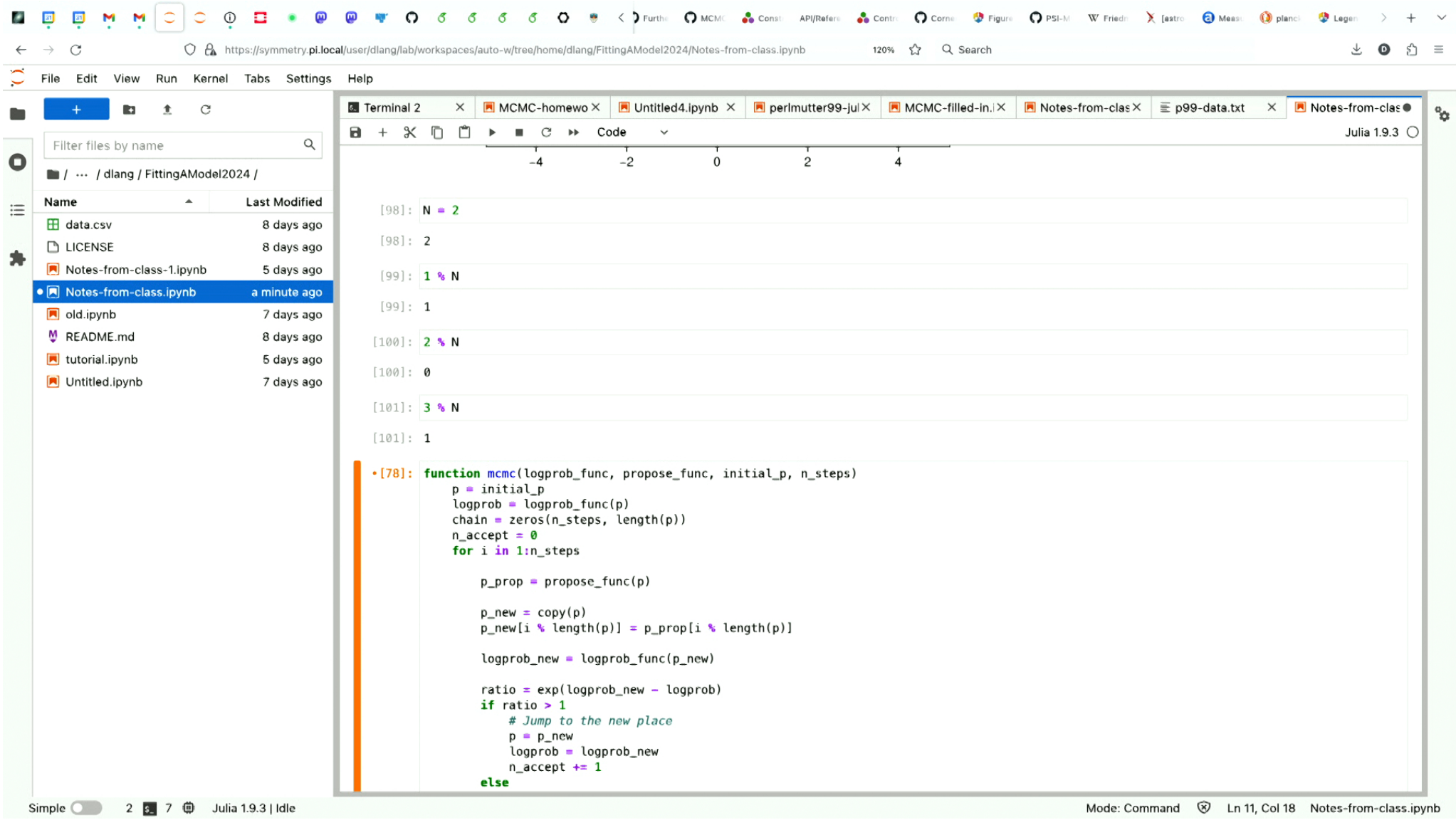
tutorial.ipynb 5 days ago
Untitled.ipynb 7 days ago
-4 -2 0 2 4
[98]: N = 2
[98]: 2
[99]: 1 % N
[99]: 1
[100]: 2 % N
[100]: 0
[78]:
function mcmc(logprob_func, propose_func, initial_p, n_steps)
p = initial_p
logprob = logprob_func(p)
chain = zeros(n_steps, length(p))
n_accept = 0
for i in 1:n_steps
p_prop = propose_func(p)
p_new = copy(p)
p_new[i % length(p)] = p_prop[i % length(p)]
logprob_new = logprob_func(p_new)
ratio = exp(logprob_new - logprob)
if ratio > 1
# Jump to the new place
p = p_new
logprob = logprob_new
n_accept += 1
else
# Jump to the new place with probability "ratio"
u = rand()
if u < ratio
Jump to the new place
Simple 2 7 Julia 1.9.3 | Idle
Mode: Edit Ln 11, Col 18 Notes-from-class.ipynb


https://symmetry.pi.local/user/dlang/lab/workspaces/auto-w/tree/home/dlang/FittingAModel2024/Notes-from-class.ipynb
File Edit View Run Kernel Tabs Settings Help
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Name
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old.ipynb 7 days ago
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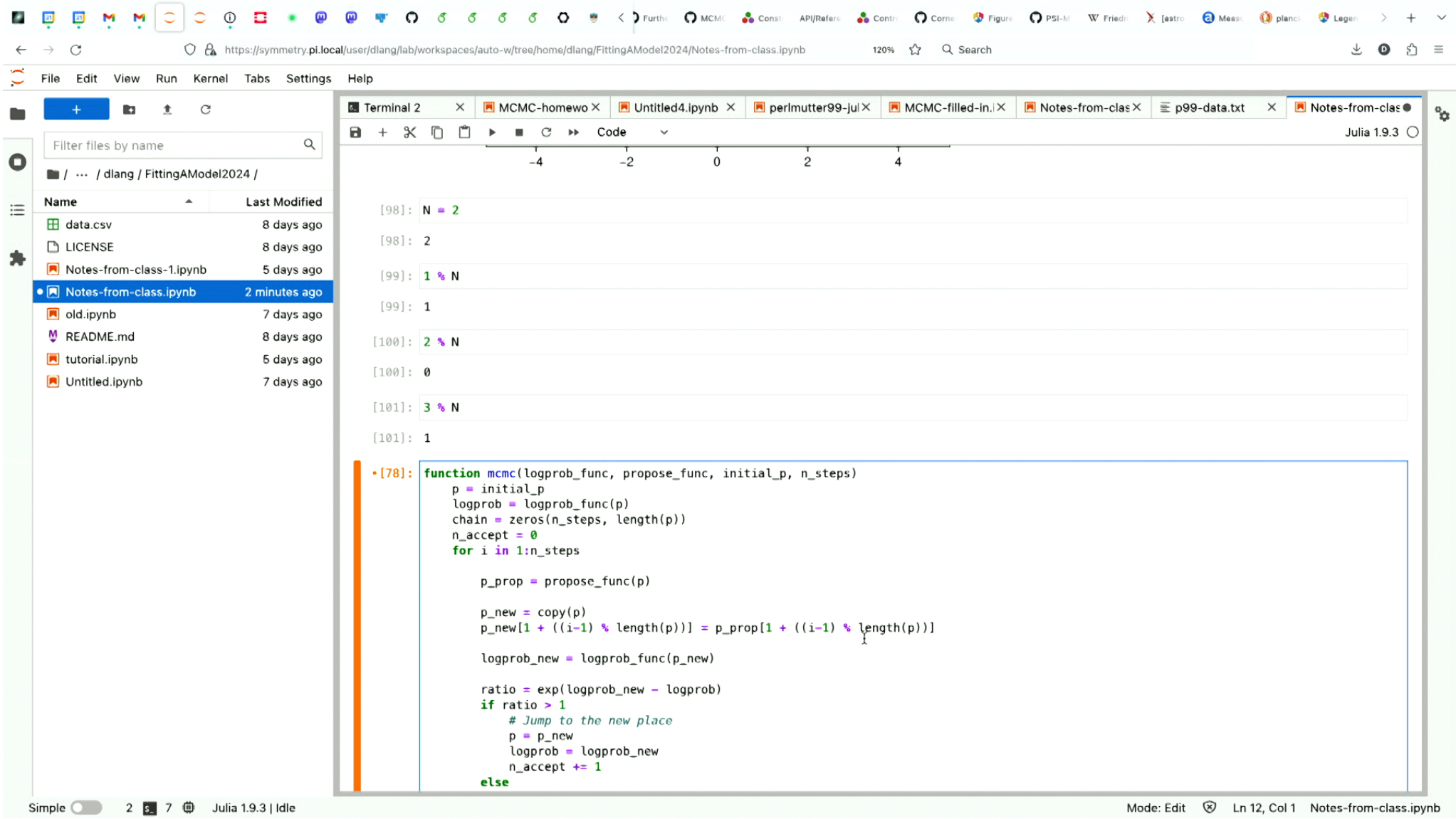
tutorial.ipynb 5 days ago
Untitled.ipynb 7 days ago
−4 −2 0 2 4
[98]: N = 2
[98]: 2
[99]: 1 % N
[99]: 1
[100]: 2 % N
[100]: 0
[101]: 3 % N
[101]: 1
[78]: function mcmc(logprob_func, propose_func, initial_p, n_steps)
p = initial_p
logprob = logprob_func(p)
chain = zeros(n_steps, length(p))
n_accept = 0
for i in 1:n_steps
p_prop = propose_func(p)
p_new = copy(p)
p_new[i % length(p)] = p_prop[i % length(p)]
logprob_new = logprob_func(p_new)
ratio = exp(logprob_new - logprob)
if ratio > 1
# Jump to the new place
p = p_new
logprob = logprob_new
n_accept += 1
else
Simple 2 7 Julia 1.9.3 | Idle
Mode: Command Ln 11, Col 18 Notes-from-class.ipynb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File Edit View Run Kernel Tabs Settings Help
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Notes-from-class.ipynb 2 minutes ago
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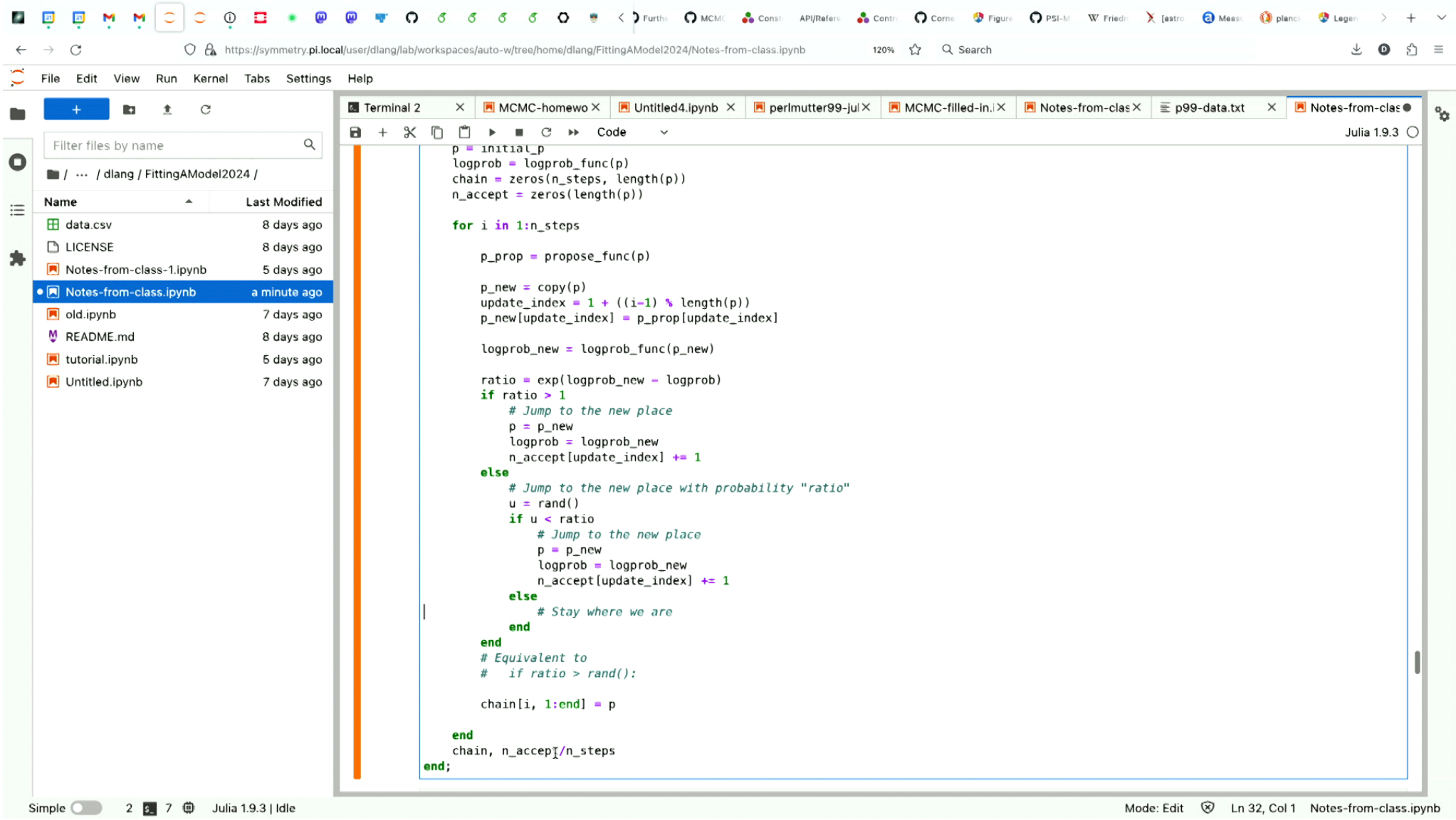
README.md 8 days ago
tutorial.ipynb 5 days ago
Untitled.ipynb 7 days ago
[98]: N = 2
[98]: 2
[99]: 1 % N
[99]: 1
[100]: 2 % N
[100]: 0
[101]: 3 % N
[101]: 1
[78]:
function mcmc(logprob_func, propose_func, initial_p, n_steps)
p = initial_p
logprob = logprob_func(p)
chain = zeros(n_steps, length(p))
n_accept = 0
for i in 1:n_steps
p_prop = propose_func(p)
p_new = copy(p)
p_new[1 + ((i-1) % length(p))] = p_prop[1 + ((i-1) % length(p))]
logprob_new = logprob_func(p_new)
ratio = exp(logprob_new - logprob)
if ratio > 1
# Jump to the new place
p = p_new
logprob = logprob_new
n_accept += 1
else
Simple
Julia 1.9.3 | Idle
Mode: Edit
Ln 12, Col 1
Notes-from-class.ipynb


https://symmetry.pi.local/user/dlang/lab/workspaces/auto-w/tree/home/dlang/FittingAModel2024/Notes-from-class.ipynb
File Edit View Run Kernel Tabs Settings Help
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Name
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Notes-from-class-1.ipynb 5 days ago
Notes-from-class.ipynb a minute ago
old.ipynb 7 days ago
README.md 8 days ago
tutorial.ipynb 5 days ago
Untitled.ipynb 7 days ago
p = initial_p
logprob = logprob_func(p)
chain = zeros(n_steps, length(p))
n_accept = zeros(length(p))
for i in 1:n_steps
p_prop = propose_func(p)
p_new = copy(p)
update_index = 1 + ((i-1) % length(p))
p_new[update_index] = p_prop[update_index]
logprob_new = logprob_func(p_new)
ratio = exp(logprob_new - logprob)
if ratio > 1
# Jump to the new place
p = p_new
logprob = logprob_new
n_accept[update_index] += 1
else
# Jump to the new place with probability "ratio"
u = rand()
if u < ratio
# Jump to the new place
p = p_new
logprob = logprob_new
n_accept[update_index] += 1
else
# Stay where we are
end
end
Equivalent to
if ratio > rand():
chain[i, 1:end] = p
end
chain, n_accept/n_steps
end;
Simple
2 7
Julia 1.9.3 | Idle
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Ln 32, Col 1
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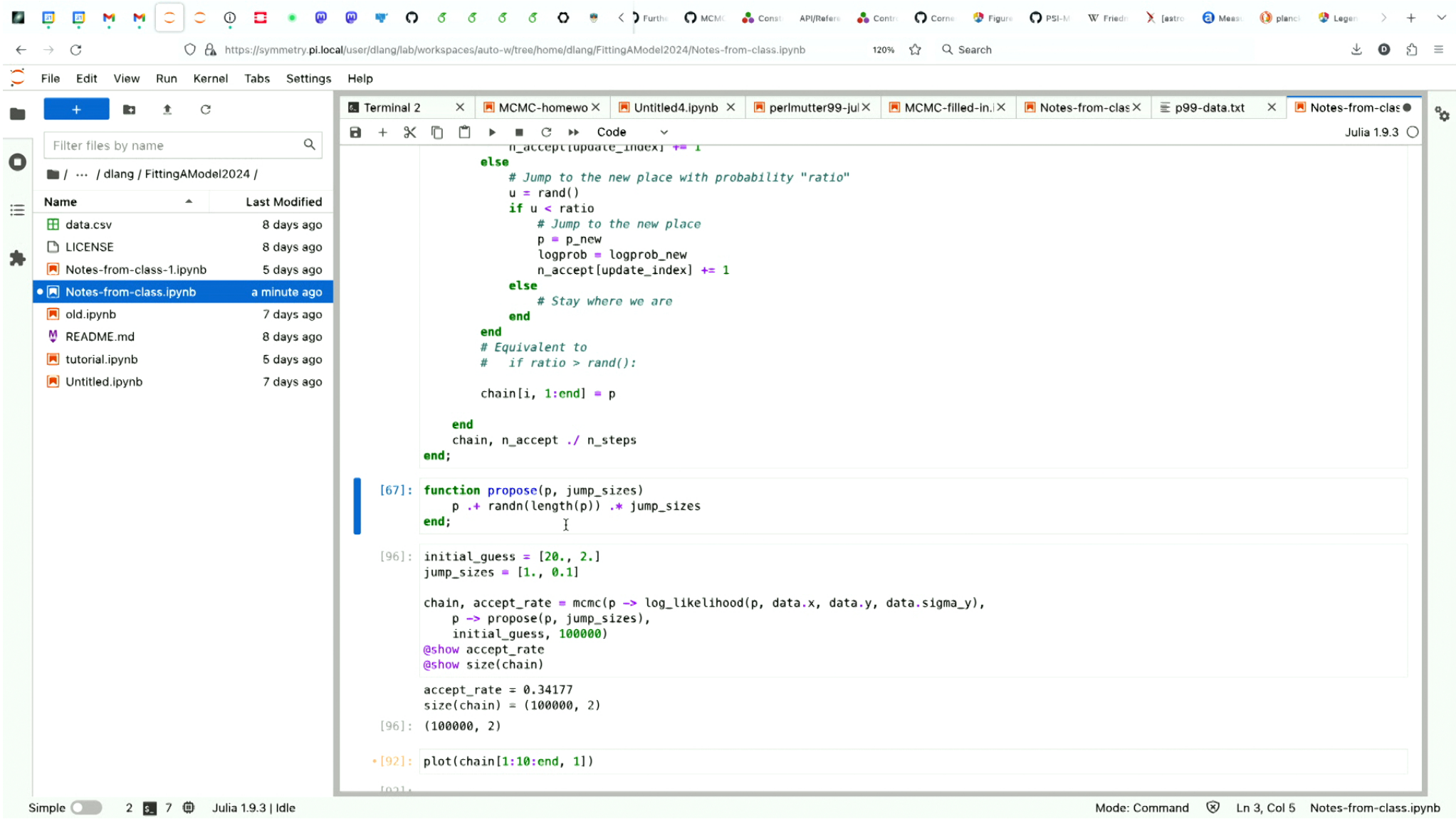
https://symmetry.pi.local/user/dlang/lab/workspaces/auto-w/tree/home/dlang/FittingAModel2024/Notes-from-class.ipynb
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Terminal 2
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Code
Julia 1.9.3
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Name
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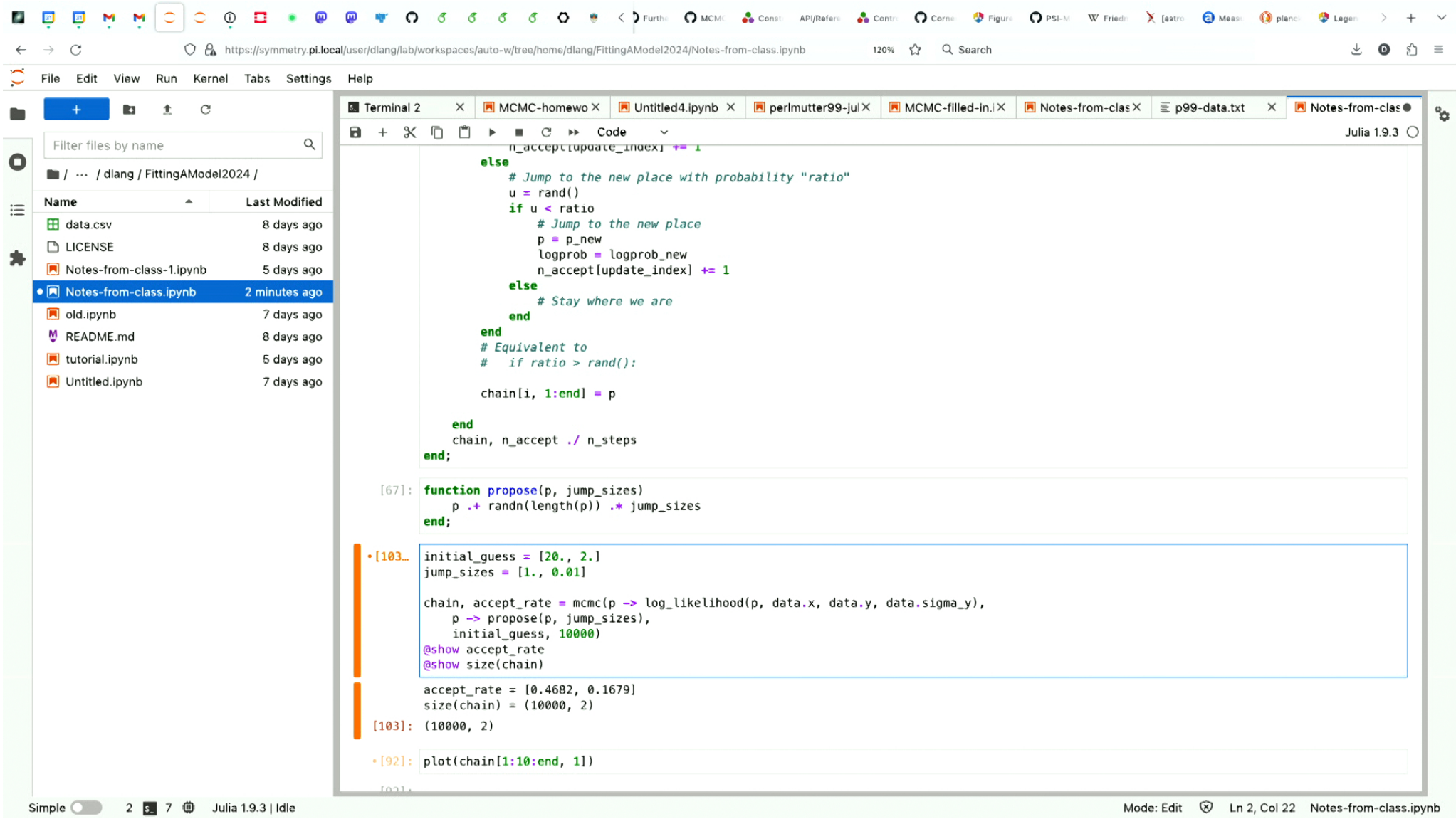
LICENSE 8 days ago
Notes-from-class-1.ipynb 5 days ago
Notes-from-class.ipynb a minute ago
old.ipynb 7 days ago
README.md 8 days ago
tutorial.ipynb 5 days ago
Untitled.ipynb 7 days ago
# Jump to the new place with probability "ratio"
u = rand()
if u < ratio
# Jump to the new place
p = p_new
logprob = logprob_new
n_accept[update_index] += 1
else
# Stay where we are
end
end
Equivalent to
if ratio > rand():
chain[i, 1:end] = p
end
chain, n_accept ./ n_steps
end;
[67]:
function propose(p, jump_sizes)
p .+ randn(length(p)) .* jump_sizes
end;
[96]:
initial_guess = [20., 2.]
jump_sizes = [1., 0.1]
chain, accept_rate = mcmc(p -> log_likelihood(p, data.x, data.y, data.sigma_y),
p -> propose(p, jump_sizes),
initial_guess, 100000)
@show accept_rate
@show size(chain)
accept_rate = 0.34177
size(chain) = (100000, 2)
[96]: (100000, 2)
[92]:
plot(chain[1:10:end, 1])
Simple
Julia 1.9.3 | Idle
Mode: Command
Ln 3, Col 5
Notes-from-class.ipynb


https://symmetry.pi.local/user/dlang/lab/workspaces/auto-w/tree/home/dlang/FittingAModel2024/Notes-from-class.ipynb
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Notes-from-class.ipynb 2 minutes ago
old.ipynb 7 days ago
README.md 8 days ago
tutorial.ipynb 5 days ago
Untitled.ipynb 7 days ago
n_accept[update_index] += 1
else
# Jump to the new place with probability "ratio"
u = rand()
if u < ratio
# Jump to the new place
p = p_new
logprob = logprob_new
n_accept[update_index] += 1
else
# Stay where we are
end
end
Equivalent to
if ratio > rand():
chain[i, 1:end] = p
end
chain, n_accept ./ n_steps
end;
[67]:
function propose(p, jump_sizes)
p .+ randn(length(p)) .* jump_sizes
end;
[103…
initial_guess = [20., 2.]
jump_sizes = [1., 0.01]
chain, accept_rate = mcmc(p -> log_likelihood(p, data.x, data.y, data.sigma_y),
p -> propose(p, jump_sizes),
initial_guess, 10000)
@show accept_rate
@show size(chain)
accept_rate = [0.4682, 0.1679]
size(chain) = (10000, 2)
[103]:
(10000, 2)
[92]:
plot(chain[1:10:end, 1])
Simple
2 7
Julia 1.9.3 | Idle
Mode: Edit
Ln 2, Col 22
Notes-from-class.ipynb

https://symmetry.pi.local/user/dlang/lab/workspaces/auto-w/tree/home/dlang/FittingAModel2024/Notes-from-class.ipynb

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Terminal 2 | MCMC-homewo | Untitled4.ipynb | perlmutter99-jul | MCMC-filled-in. | Notes-from-clas | p99-data.txt | Notes-from-clas

Code Julia 1.9.3

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Notes-from-class.ipynb	2 minutes ago
old.ipynb	7 days ago
README.md	8 days ago
tutorial.ipynb	5 days ago
Untitled.ipynb	7 days ago

```
            if u < ratio
                # Jump to the new place
                p = p_new
                logprob = logprob_new
                n_accept[update_index] += 1
            else
                # Stay where we are
            end
        end
        # Equivalent to
        #   if ratio > rand():

        chain[i, 1:end] = p

    end
    chain, n_accept ./ (n_steps ./ length(p))
end;
```

[67]:
```
function propose(p, jump_sizes)
    p .+ randn(length(p)) .* jump_sizes
end;
```

[107]:
```
initial_guess = [20., 2.]
jump_sizes = [1., 0.0001]

chain, accept_rate = mcmc(p -> log_likelihood(p, data.x, data.y, data.sigma_y),
    p -> propose(p, jump_sizes),
    initial_guess, 10000)
@show accept_rate
@show size(chain)
```

```
accept_rate = [0.9362, 0.9982]
size(chain) = (10000, 2)
```

[107]:
```
(10000, 2)
```

[92]:
```
plot(chain[1:10:end, 1])
```

[92]:

Simple 2 7 Julia 1.9.3 | Idle Saving started Mode: Command Ln 1, Col 22 Notes-from-class.ipynb

https://symmetry.pi.local/user/dlang/lab/workspaces/auto-w/tree/home/dlang/FittingAModel2024/Notes-from-class.ipynb

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Notes-from-class.ipynb	a minute ago
old.ipynb	7 days ago
README.md	8 days ago
tutorial.ipynb	5 days ago
Untitled.ipynb	7 days ago

```
            if u < ratio
                # Jump to the new place
                p = p_new
                logprob = logprob_new
                n_accept[update_index] += 1
            else
                # Stay where we are
            end
        end
        # Equivalent to
        #   if ratio > rand():

        chain[i, 1:end] = p

    end
    chain, n_accept ./ (n_steps ./ length(p))
end;
```

[67]:
```
function propose(p, jump_sizes)
    p .+ randn(length(p)) .* jump_sizes
end;
```

[110…
```
initial_guess = [20., 2.]
jump_sizes = [2., 0.1]

chain, accept_rate = mcmc(p -> log_likelihood(p, data.x, data.y, data.sigma_y),
    p -> propose(p, jump_sizes),
    initial_guess, 10000)
@show accept_rate
@show size(chain)
```

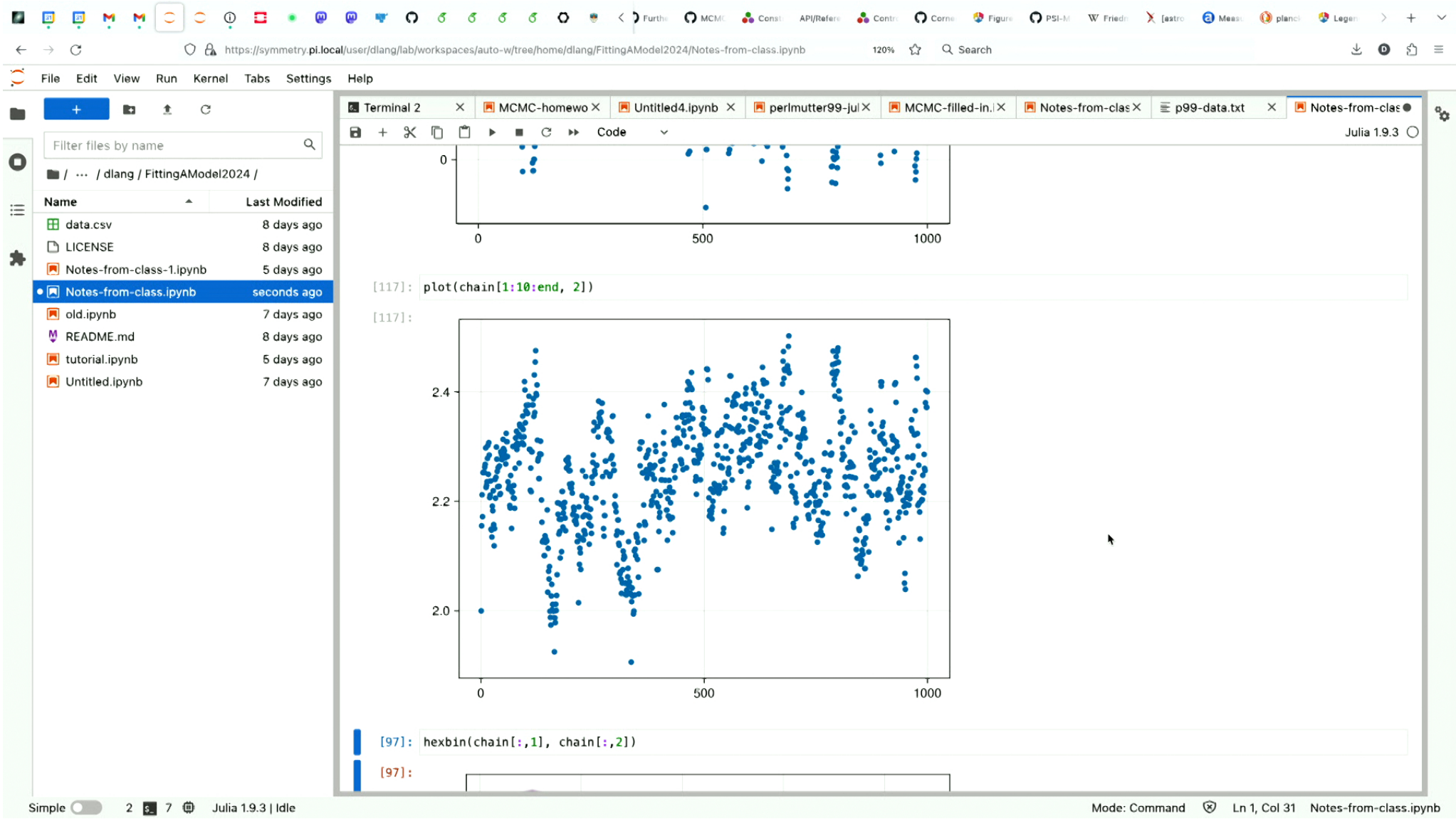
```
accept_rate = [0.9352, 0.3474]
size(chain) = (10000, 2)
```

[110]:
```
(10000, 2)
```

[92]:
```
plot(chain[1:10:end, 1])
```

[92]:

Simple 2 7 Julia 1.9.3 | Idle Mode: Edit Ln 2, Col 16 Notes-from-class.ipynb


https://symmetry.pi.local/user/dlang/lab/workspaces/auto-w/tree/home/dlang/FittingAModel2024/Notes-from-class.ipynb
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Terminal 2
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Code
Julia 1.9.3
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Name
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Notes-from-class.ipynb seconds ago
old.ipynb 7 days ago
README.md 8 days ago
tutorial.ipynb 5 days ago
Untitled.ipynb 7 days ago
[117]: plot(chain[1:10:end, 2])
[117]:
2.4
2.2
2.0
0
500
1000
[97]: hexbin(chain[:,1], chain[:,2])
[97]:
Simple
Julia 1.9.3 | Idle
Mode: Command
Ln 1, Col 31
Notes-from-class.ipynb

https://symmetry.pi.local/user/dlang/lab/workspaces/auto-w/tree/home/dlang/FittingAModel2024/Notes-from-class.ipynb

File Edit View Run Kernel Tabs Settings Help

Terminal 2 | MCMC-homewo | Untitled4.ipynb | perlmutter99-jul | MCMC-filled-in. | Notes-from-clas | p99-data.txt | Notes-from-clas

Code Julia 1.9.3

Filter files by name

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Name	Last Modified
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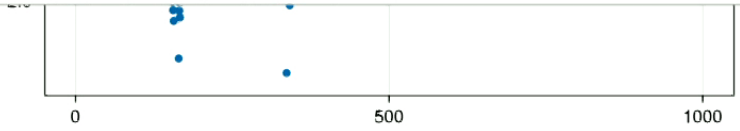
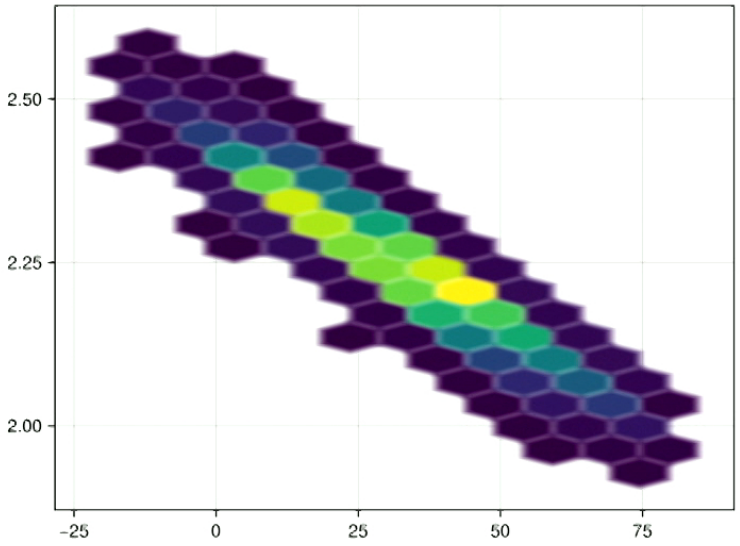
Notes-from-class-1.ipynb	5 days ago
Notes-from-class.ipynb	seconds ago
old.ipynb	7 days ago
README.md	8 days ago
tutorial.ipynb	5 days ago
Untitled.ipynb	7 days ago



[97]:
```
hexbin(chain[:,1], chain[:,2])
```

[97]:



[90]:
```
fig, ax, hm = heatmap(b_grid, m_grid, exp.(ll_grid))
Colorbar(fig[:, end+1], hm)
scatter!(b_opt, m_opt, color=:red)
fig
```

Simple 2 7 Julia 1.9.3 | Idle Mode: Edit Ln 1, Col 31 Notes-from-class.ipynb

https://symmetry.pi.local/user/dlang/lab/workspaces/auto-w/tree/home/dlang/FittingAModel2024/Notes-from-class.ipynb

File Edit View Run Kernel Tabs Settings Help

Terminal 2 | MCMC-homewo | Untitled4.ipynb | perlmutter99-jul | MCMC-filled-in. | Notes-from-clas | p99-data.txt | Notes-from-clas

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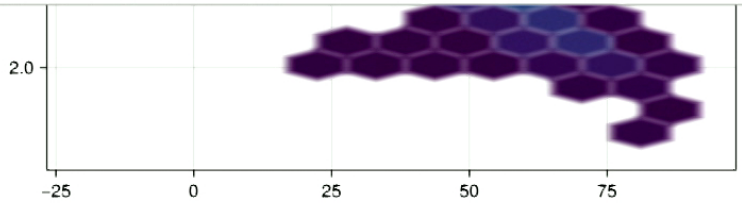
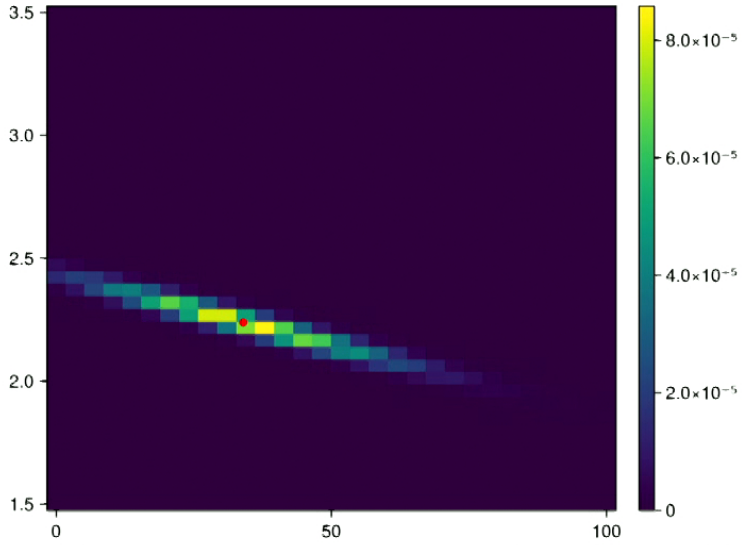
Notes-from-class.ipynb	seconds ago
old.ipynb	7 days ago
README.md	8 days ago
tutorial.ipynb	5 days ago
Untitled.ipynb	7 days ago

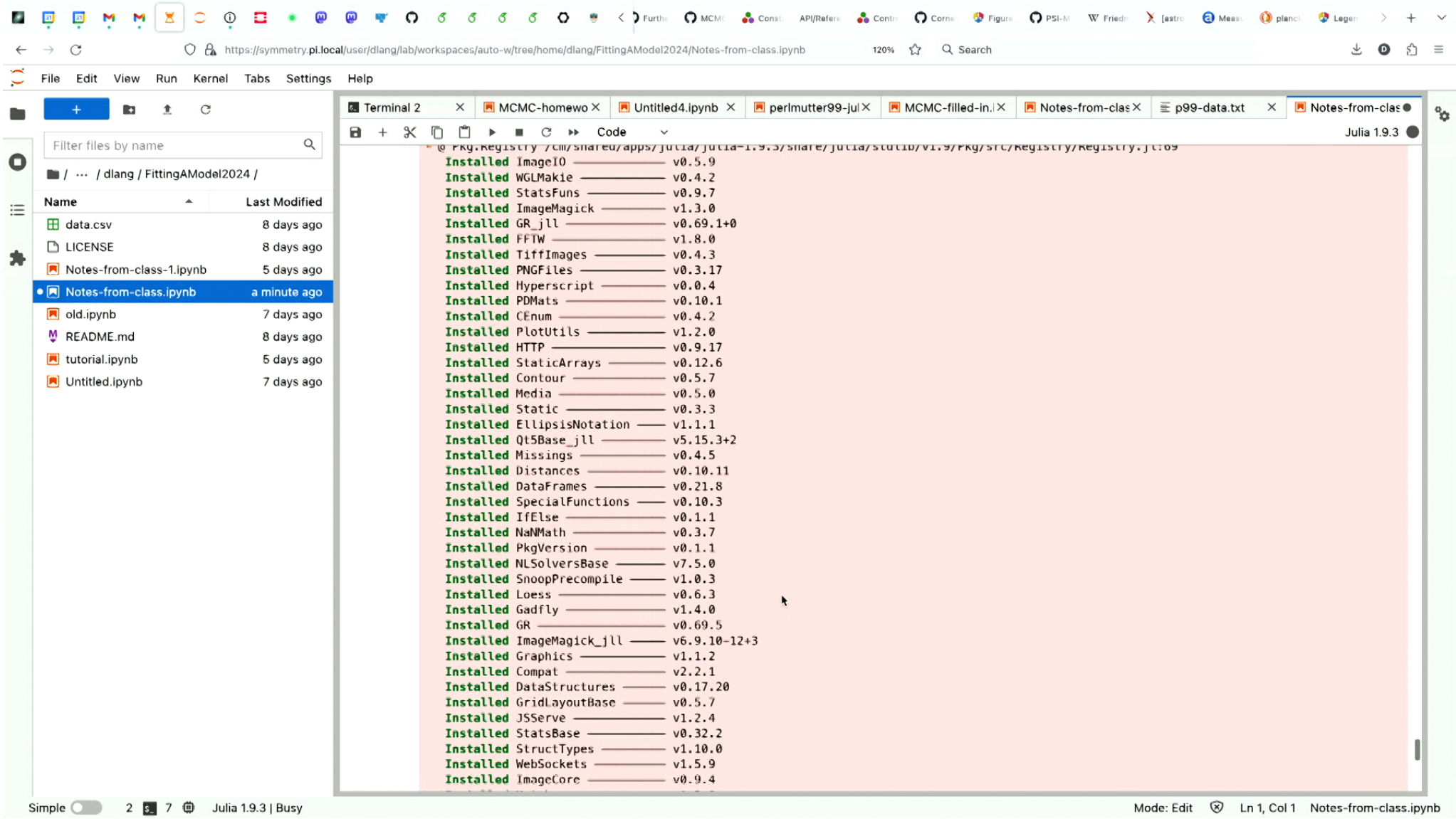


[90]:
```
fig, ax, hm = heatmap(b_grid, m_grid, exp.(ll_grid))
Colorbar(fig[:, end+1], hm)
scatter!(b_opt, m_opt, color=:red)
fig
```

[90]:



Simple 2 7 Julia 1.9.3 | Idle Mode: Command Ln 4, Col 4 Notes-from-class.ipynb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Installed ImageIO ── v0.5.9
Installed WGLMakie ── v0.4.2
Installed StatsFuns ── v0.9.7
Installed ImageMagick ── v1.3.0
Installed GR_jll ── v0.69.1+0
Installed FFTW ── v1.8.0
Installed TiffImages ── v0.4.3
Installed PNGFiles ── v0.3.17
Installed Hyperscript ── v0.0.4
Installed PDMats ── v0.10.1
Installed CEnum ── v0.4.2
Installed PlotUtils ── v1.2.0
Installed HTTP ── v0.9.17
Installed StaticArrays ── v0.12.6
Installed Contour ── v0.5.7
Installed Media ── v0.5.0
Installed Static ── v0.3.3
Installed EllipsisNotation ── v1.1.1
Installed Qt5Base_jll ── v5.15.3+2
Installed Missings ── v0.4.5
Installed Distances ── v0.10.11
Installed DataFrames ── v0.21.8
Installed SpecialFunctions ── v0.10.3
Installed IfElse ── v0.1.1
Installed NaNMath ── v0.3.7
Installed PkgVersion ── v0.1.1
Installed NLSolversBase ── v7.5.0
Installed SnoopPrecompile ── v1.0.3
Installed Loess ── v0.6.3
Installed Gadfly ── v1.4.0
Installed GR ── v0.69.5
Installed ImageMagick_jll ── v6.9.10-12+3
Installed Graphics ── v1.1.2
Installed Compat ── v2.2.1
Installed DataStructures ── v0.17.20
Installed GridLayoutBase ── v0.5.7
Installed JSServe ── v1.2.4
Installed StatsBase ── v0.32.2
Installed StructTypes ── v1.10.0
Installed WebSockets ── v1.5.9
Installed ImageCore ── v0.9.4
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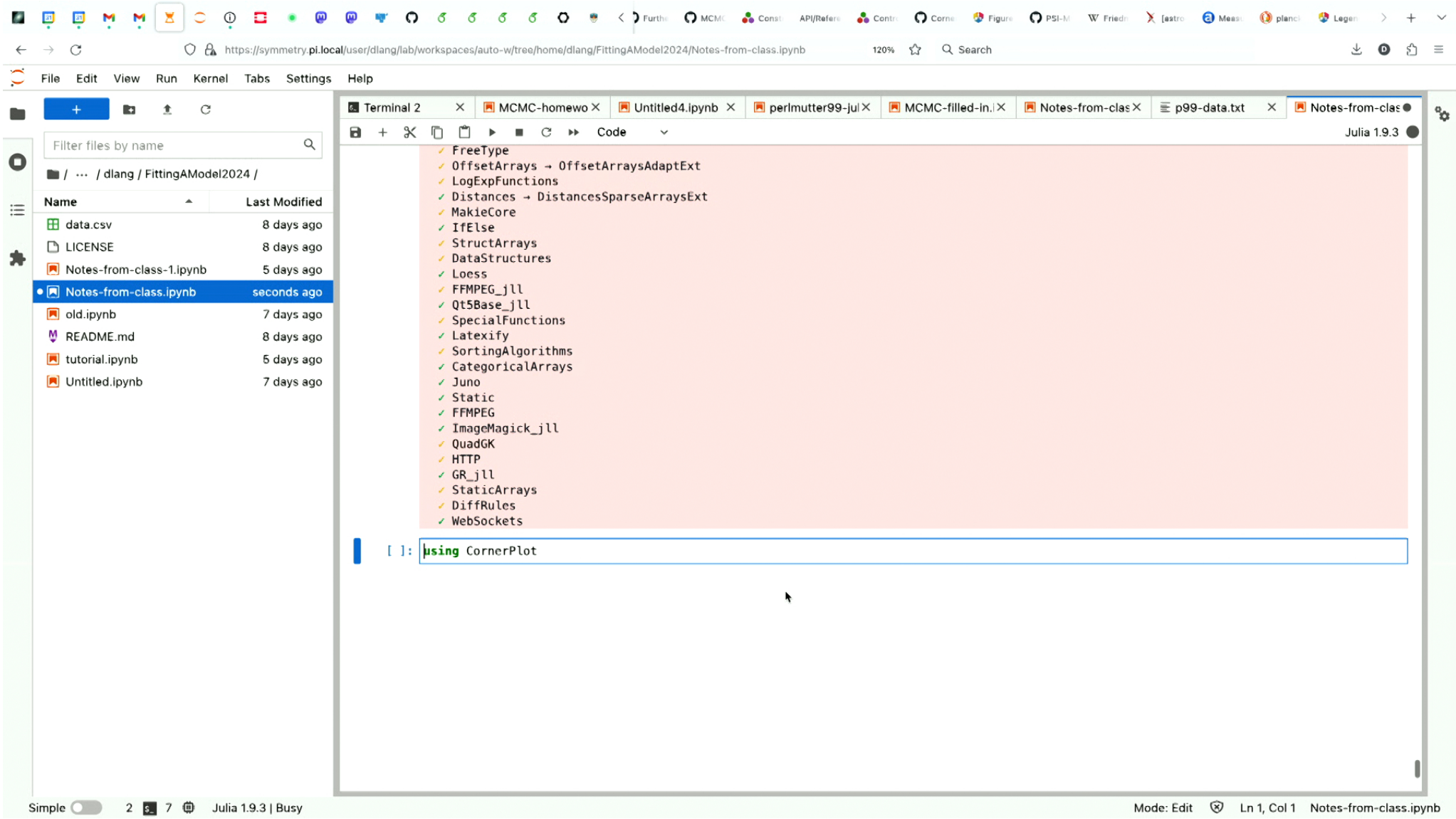
Notes-from-class.ipynb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✓ FFMPEG
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✓ QuadGK
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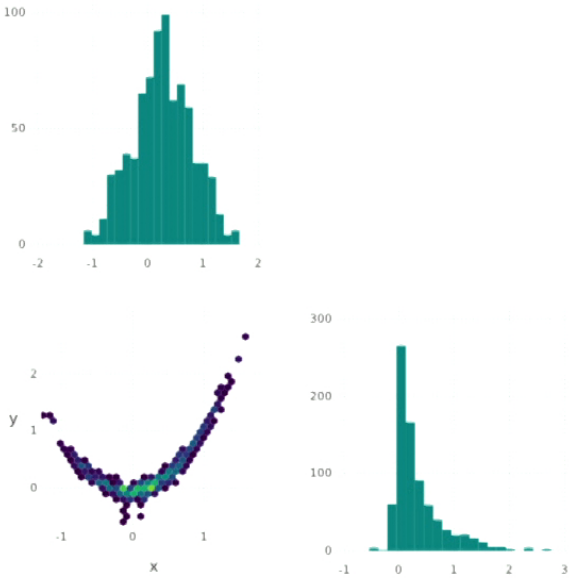
✓ DiffRules
✓ WebSockets
[ ]: using CornerPlot
Simple
Julia 1.9.3 | Busy
Mode: Edit
Ln 1, Col 1
Notes-from-class.ipynb

dimensions as a triangular matrix of subplots showing the samples in pairs of dimensions. To use make such a plot, simply call `corner` with an array of shape (nsamples, ndims) or a DataFrame containing your samples:

```
corner(df)
```

Further optional arguments can be seen in the example IJulia notebook or in the docstrings of the code.



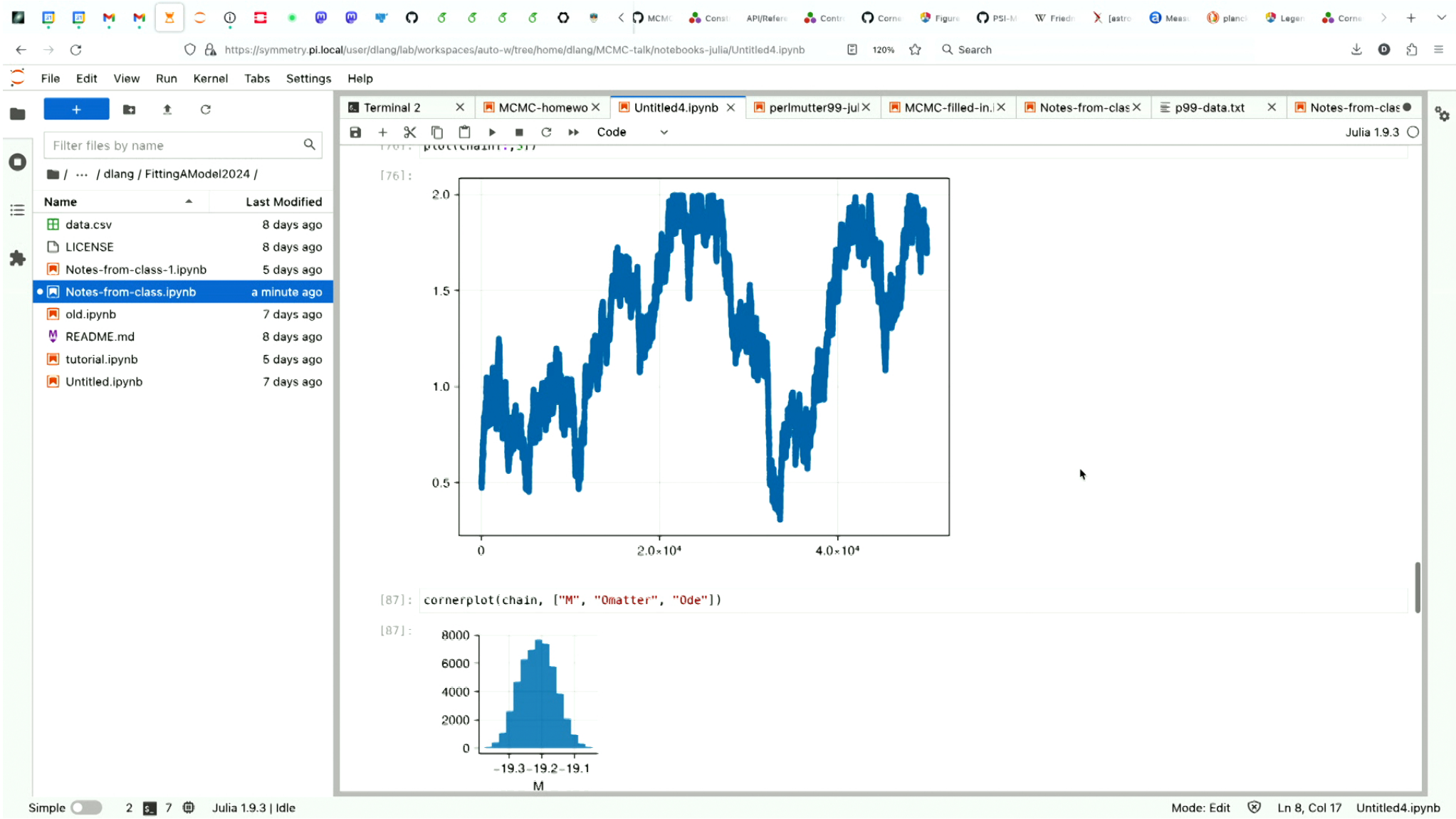
Required Packages

Compat

Gadfly

Used By Packages

No packages found.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README.md 8 days ago
tutorial.ipynb 5 days ago
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[76]:
2.0
1.5
1.0
0.5
0
2.0×10⁴
4.0×10⁴
[87]: cornerplot(chain, ["M", "Omatter", "Ode"])
[87]:
8000
6000
4000
2000
0
-19.3
-19.2
-19.1
M
Simple
2 7
Julia 1.9.3 | Idle
Mode: Edit
Ln 8, Col 17
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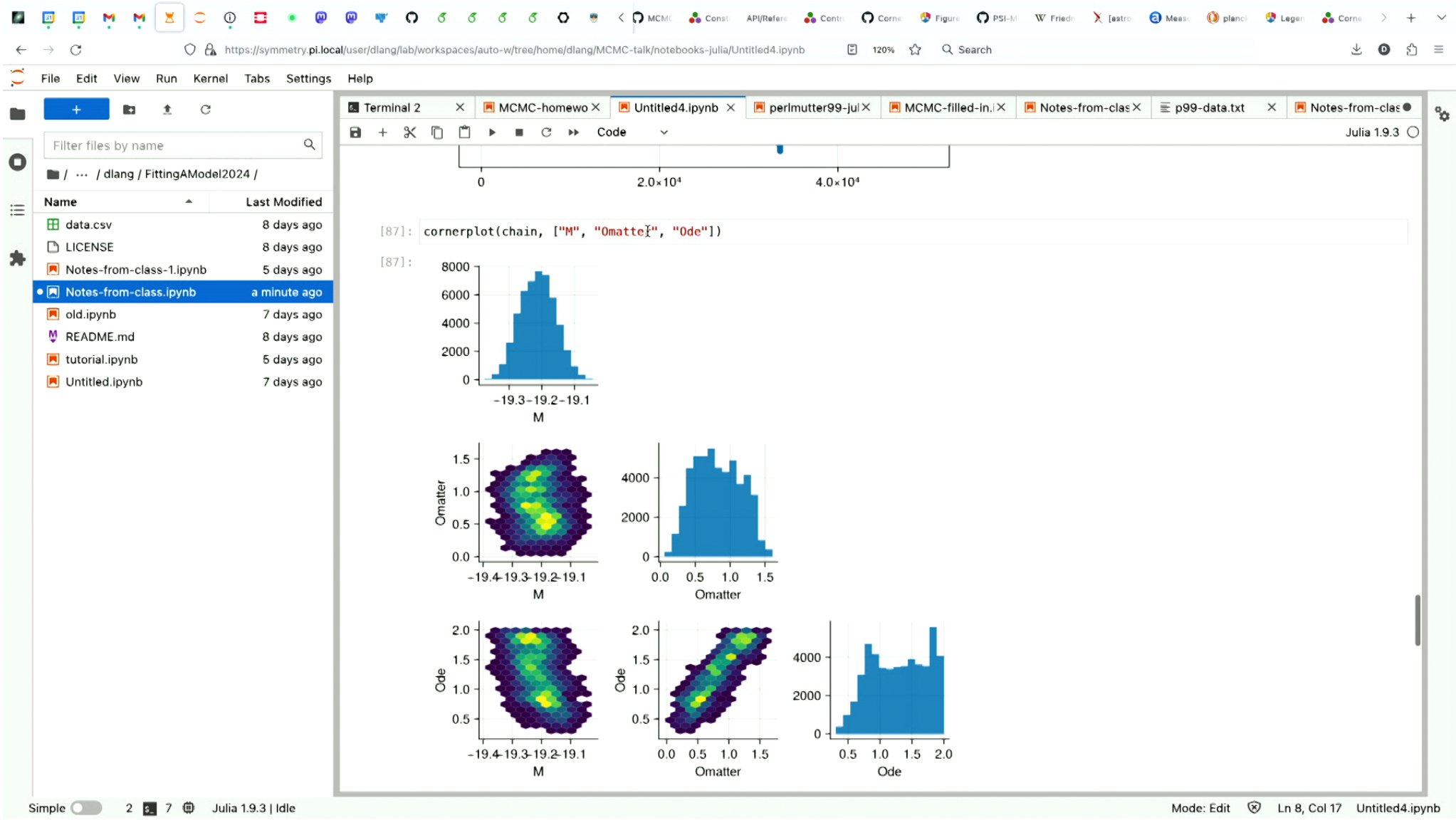
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