THE DURATION OF INTERPHENOPHASES IN WINEGRAPES

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Interphenophase: the duration between individual phenological events

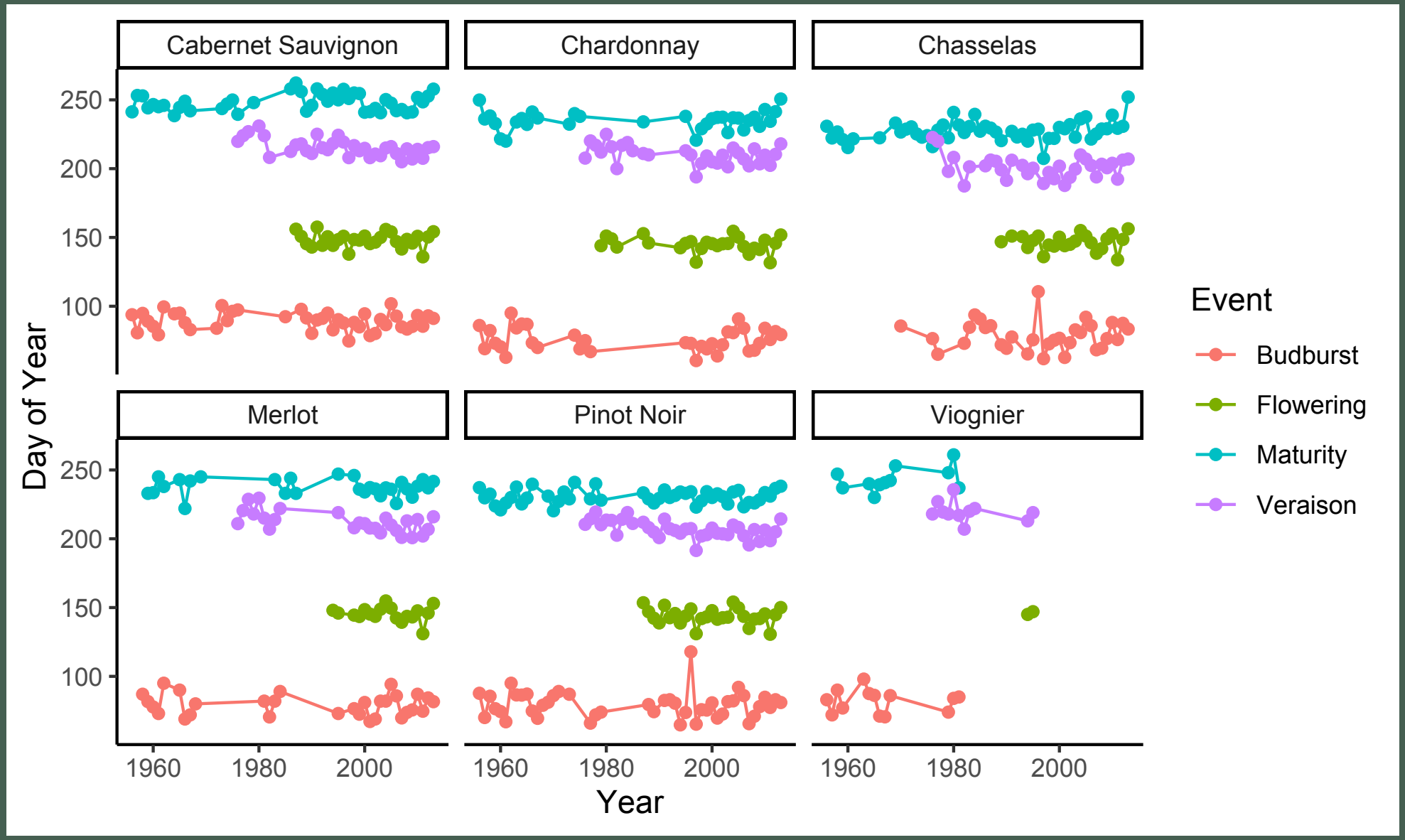
Budburst to Flowering

Flowering to Veraison

Veraison to Maturity

The Datasets: Domaine De vassal

https://amarchinthevines.org/2015/11/05/domaine-vassal-wine-worlds-heritage-site/


Cabernet Sauvignon
Chardonnay
Chasselas
Merlot
Pinot Noir
Viognier
Day of Year
250
200
150
100
1960
1980
2000
Year
Event
Budburst
Flowering
Maturity
Veraison

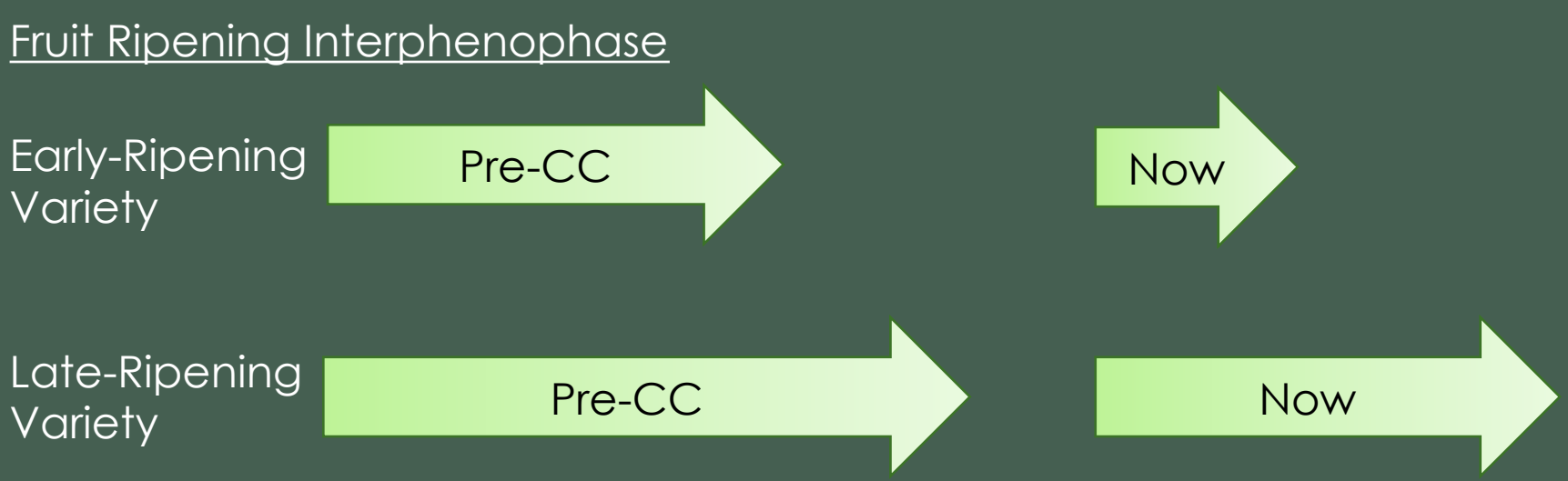
Research Questions

1. Have the durations of the interphenophases changed since the 1980s?

   - Veraison and maturity (harvest) 
   - Flowering and veraison 
   - Budburst and flowering 

Research Questions

2. If so, do these changes differ among varieties?
   - We expect to see difference among varieties.
   - Late-ripening vs early-ripening



Research Questions

3. Have growing degree days (GDD) between phenological events changed since the 1980s?

GDD Pre-CC = GDD Now

Research Questions

4. Does the required GDD of interphenophases correlate with shifts in phenological events in a way that constricts vine growth and development?

- We expect to see correlations between events and interphenophases.
- early budburst and flowering varieties  ripening GDD
- late budburst and flowering varieties  ripening GDD

Model: Duration in Days:

$$\text{Predicted Duration} \sim N(\mu_{variety}, e) \quad (1)$$

$$\mu_{variety} = \alpha_{variety} + \beta_{variety} * year \quad (2)$$

$$\alpha_{variety} \sim N(\mu_a, \sigma_a) \quad (3)$$

$$\beta_{variety} \sim N(\mu_b, \sigma_b) \quad (4)$$

Model: Duration in GDD:

$$GDD \sim N(\mu_{variety}, e) \tag{5}$$

$$\mu_{variety} = \alpha_{variety} + \beta_{variety} * year \tag{6}$$

$$\alpha_{variety} \sim N(\mu_a, \sigma_a) \tag{7}$$

$$\beta_{variety} \sim N(\mu_b, \sigma_b) \tag{8}$$

Full data (Warm Up 6000, Iterations 5000):

still have problem with low Bulk Effective Sample Size and Tail Effective Sample Size

```
> precis(modone)
174 vector or matrix parameters omitted in display. Use depth=2 to show them.
          Mean StdDev lower 0.89 upper 0.89 n_eff Rhat
mu_a    690.00  50.87     612.92     774.54   169 1.02
mu_b     -0.18   0.03      -0.22      -0.13   179 1.02
s_avar   81.22  20.18      47.77     112.08   325 1.02
s_bvar    0.08   0.01       0.06       0.09   940 1.01
sigma_y  88.71   3.00      83.93      93.45  5052 1.00
>
```

```
> #summo[grep("s\\_", rownames(summo)),]
> #summo[grep("sigma_y", rownames(summo)),]
> precis(modone)
90 vector or matrix parameters omitted in display. Use depth=2 to show them.
          Mean StdDev lower 0.89 upper 0.89 n_eff Rhat
mu_a    685.16  51.20     601.71     766.38   128 1.03
mu_b     -0.19   0.03      -0.24      -0.15   123 1.03
s_avar   79.15  16.99      53.20     106.99   470 1.01
s_bvar    0.03   0.01       0.01       0.05   212 1.02
sigma_y  96.82   3.76      91.25     103.07  3552 1.00
Warning message:
In precis(modone) : There were 56 divergent iterations during sampling.
Check the chains (trace plots, n_eff, Rhat) carefully to ensure they are valid.
>
```

```
Warning messages:
1: There were 56 divergent transitions after warmup. Increasing adapt_delta above 0.8 may hel
p. See
http://mc-stan.org/misc/warnings.html#divergent-transitions-after-warmup
2: Examine the pairs() plot to diagnose sampling problems

3: Bulk Effective Samples Size (ESS) is too low, indicating posterior means and medians may be
 unreliable.
Running the chains for more iterations may help. See
http://mc-stan.org/misc/warnings.html#bulk-ess
4: Tail Effective Samples Size (ESS) is too low, indicating posterior variances and tail quant
iles may be unreliable.
Running the chains for more iterations may help. See
http://mc-stan.org/misc/warnings.html#tail-ess
>
```

Half the varieties to see how variations among varieties effects parameter estimates.

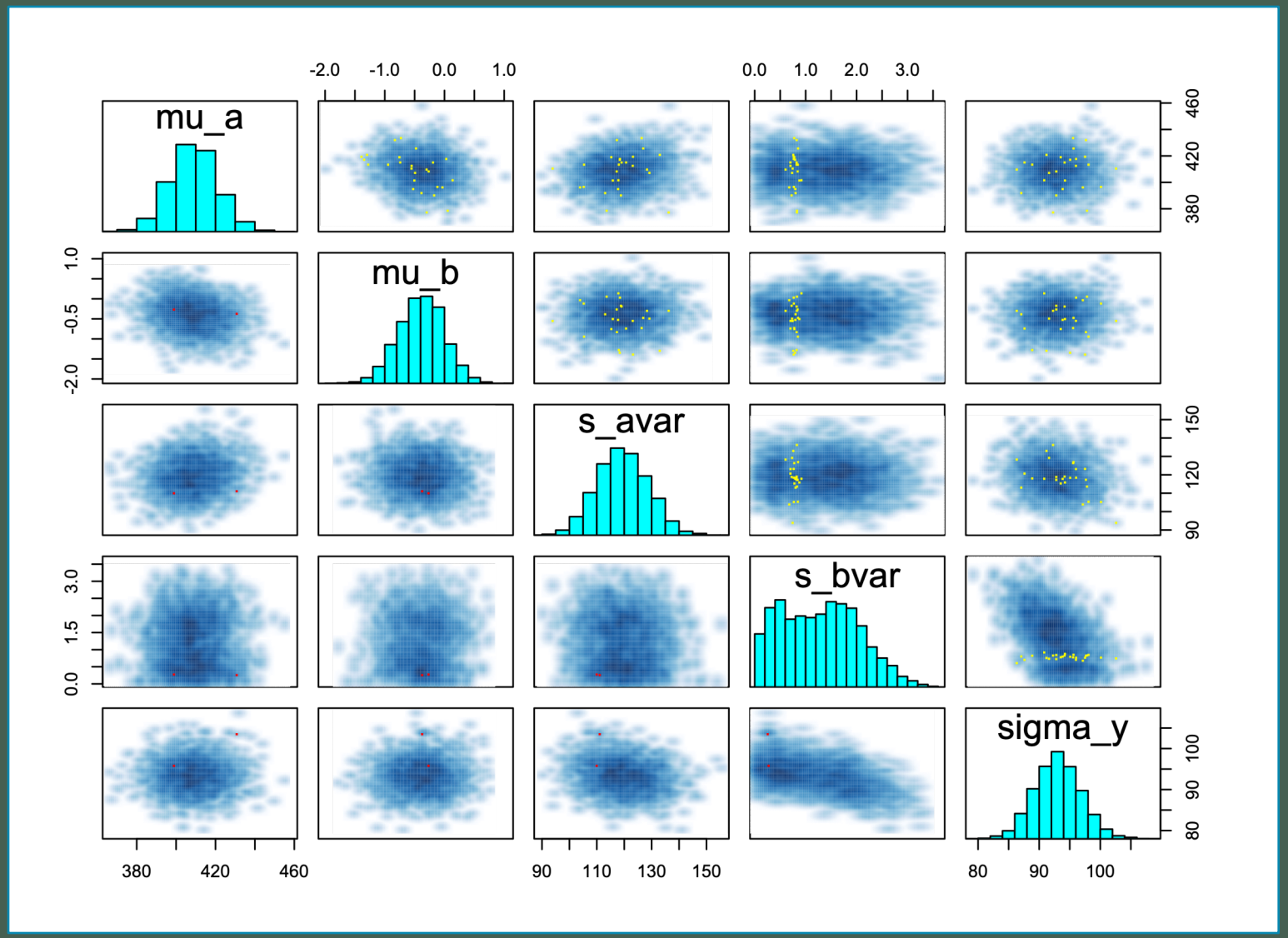
Warm Up 6000
Iterations 5000

With year hinged

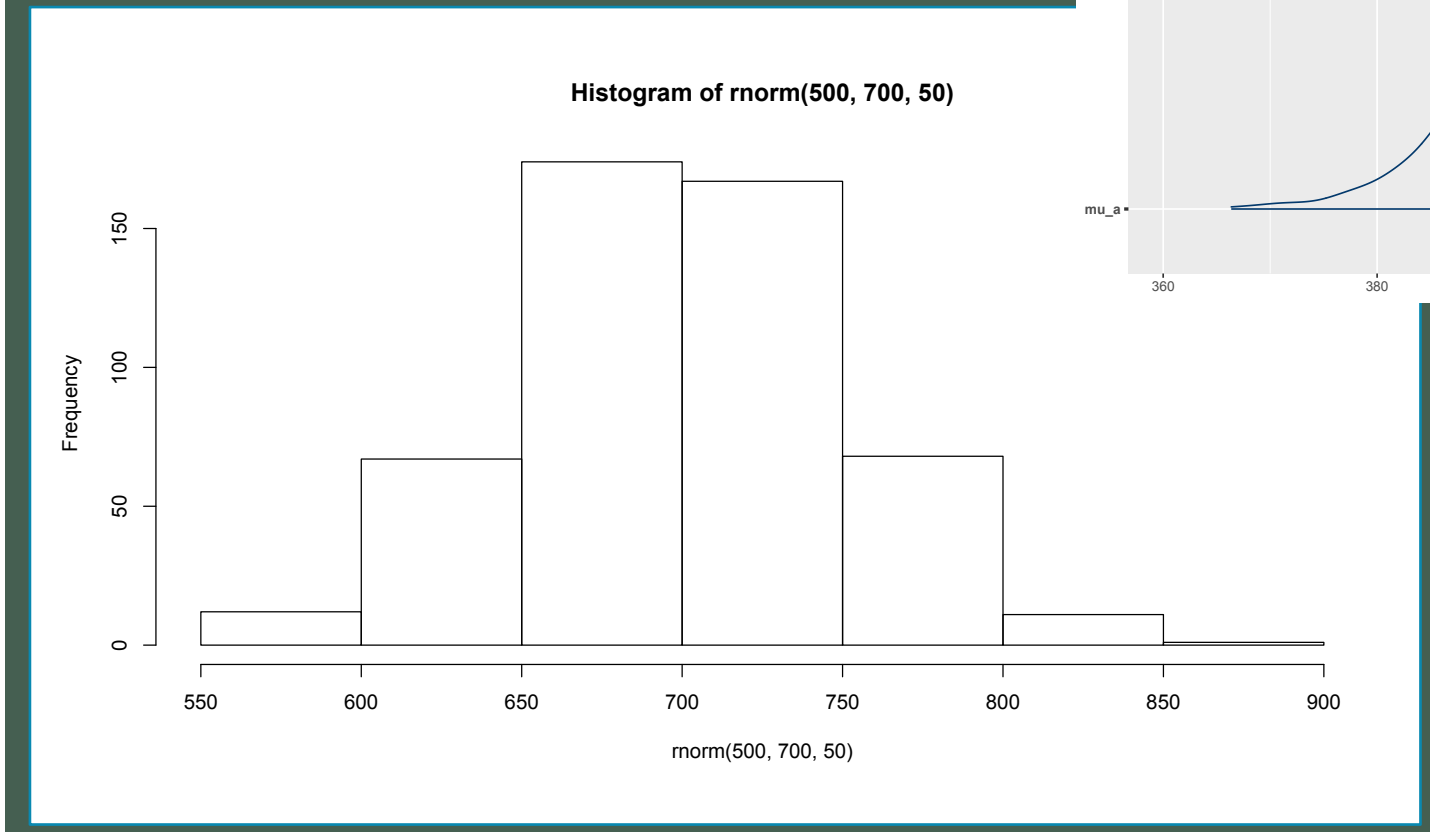
Warm Up 8000 Iterations 7000

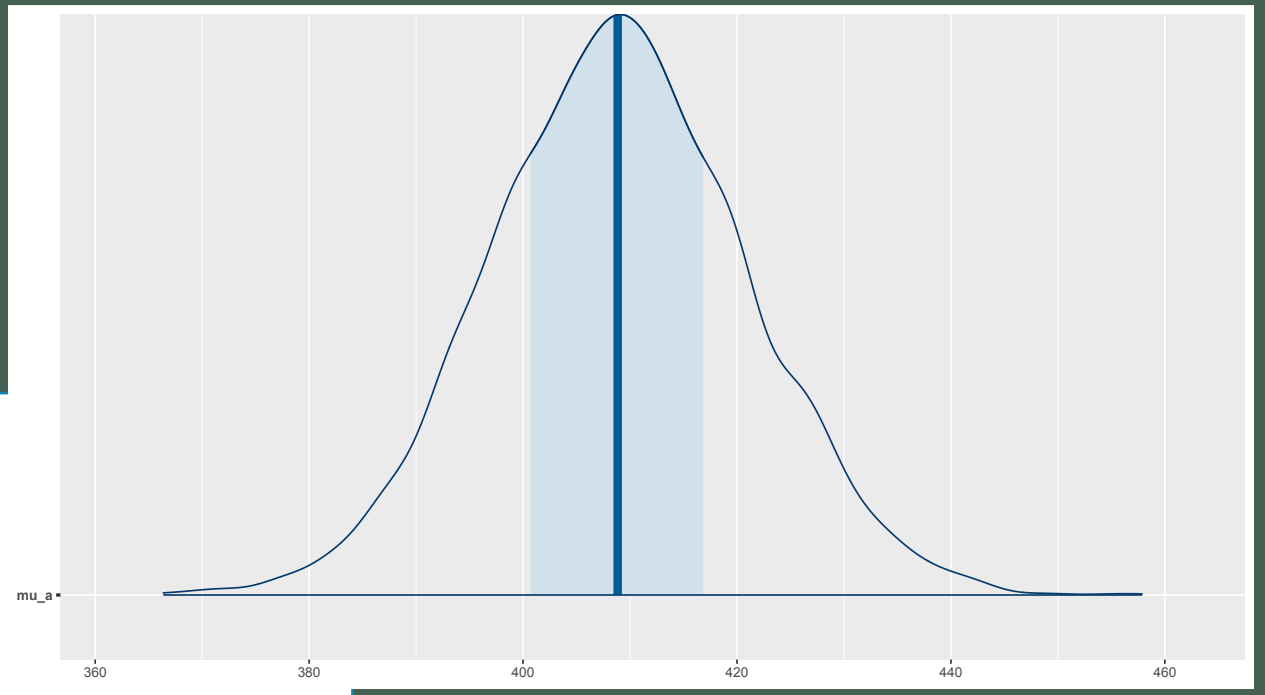
```
Chain 4:
Warning messages:
1: There were 2 divergent transitions after warmup. Increasing adapt_delta above 0.8 may help.
 See
http://mc-stan.org/misc/warnings.html#divergent-transitions-after-warmup
2: There were 26 transitions after warmup that exceeded the maximum treedepth. Increase max_tr
eedepth above 10. See
http://mc-stan.org/misc/warnings.html#maximum-treedepth-exceeded
3: There were 4 chains where the estimated Bayesian Fraction of Missing Information was low. S
ee
http://mc-stan.org/misc/warnings.html#bfmi-low
4: Examine the pairs() plot to diagnose sampling problems

5: The largest R-hat is 1.28, indicating chains have not mixed.
Running the chains for more iterations may help. See
http://mc-stan.org/misc/warnings.html#r-hat
6: Bulk Effective Samples Size (ESS) is too low, indicating posterior means and medians may be
 unreliable.
Running the chains for more iterations may help. See
http://mc-stan.org/misc/warnings.html#bulk-ess
7: Tail Effective Samples Size (ESS) is too low, indicating posterior variances and tail quant
iles may be unreliable.
Running the chains for more iterations may help. See
http://mc-stan.org/misc/warnings.html#tail-ess
> precis(modone)
266 vector or matrix parameters omitted in display. Use depth=2 to show them.
         Mean StdDev lower 0.89 upper 0.89 n_eff Rhat
mu_a    408.90  11.97     390.71     428.41  3359 1.00
mu_b     -0.39   0.38      -0.99       0.22   589 1.01
s_avar  119.40   9.30     105.78     135.36  2607 1.00
s_bvar    1.29   0.75       0.05       2.25    22 1.22
sigma_y  93.05   3.80      87.04      98.98   116 1.03
Warning message:
In precis(modone) : There were 2 divergent iterations during sampling.
Check the chains (trace plots, n_eff, Rhat) carefully to ensure they are valid.
>
```

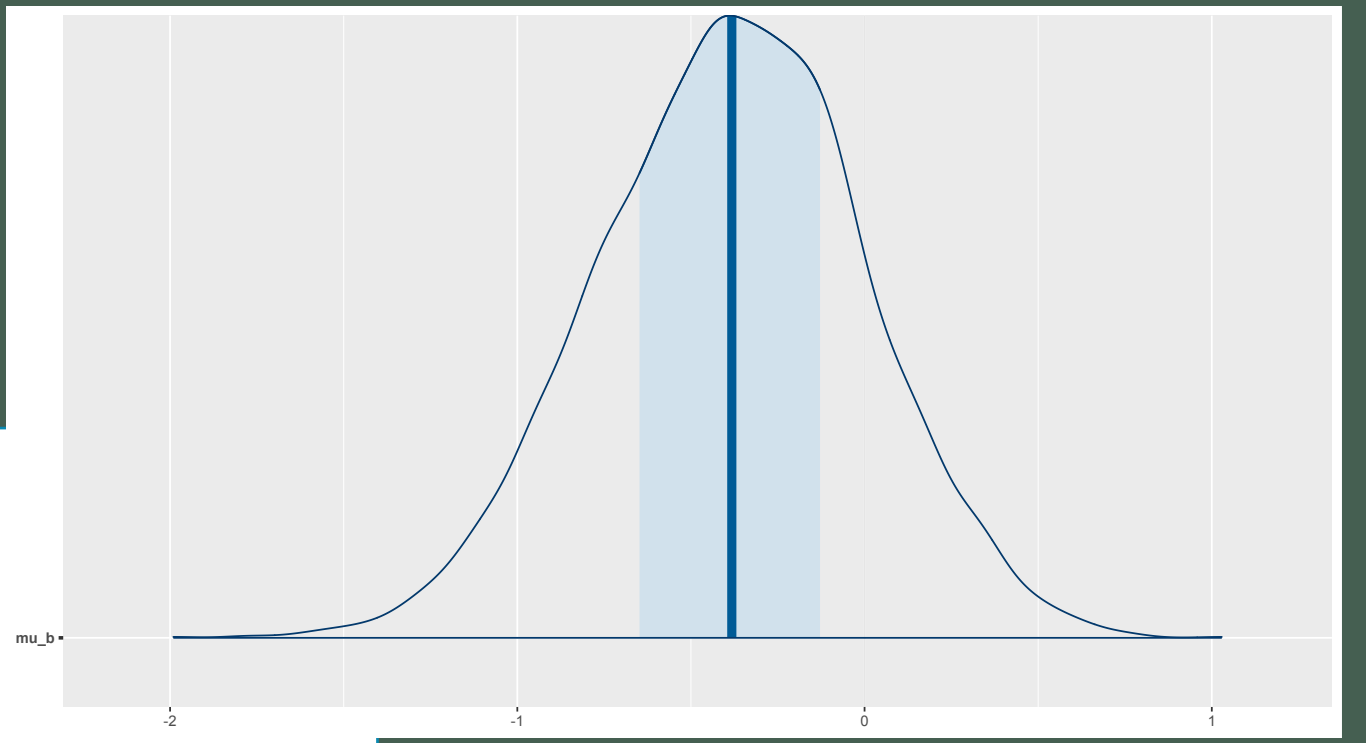

mu_a
mu_b
s_avar
s_bvar
sigma_y
-2.0 -1.0 0.0 1.0
0.0 1.0 2.0 3.0
380 420 460
-2.0 -0.5 1.0
90 110 130 150
0.0 1.5 3.0
80 90 100

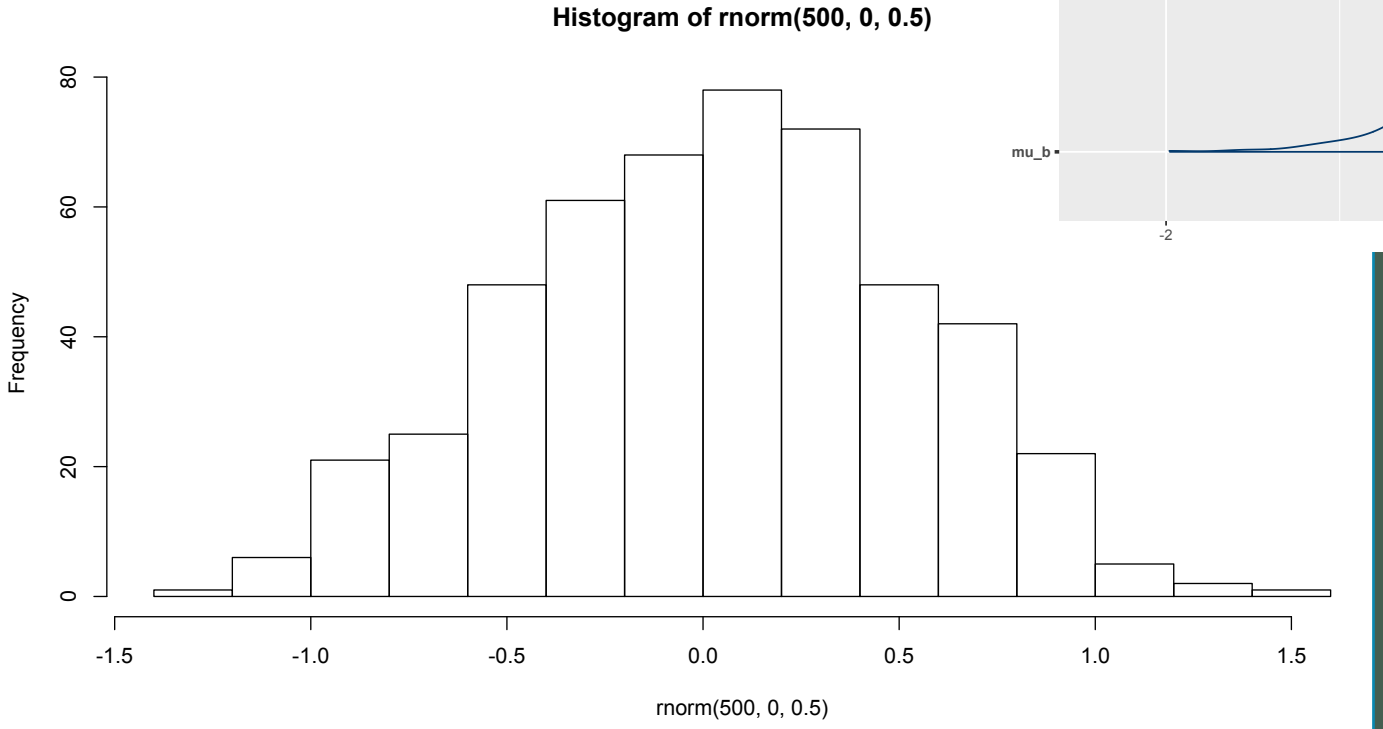
Mu_a:
priors v posteriors



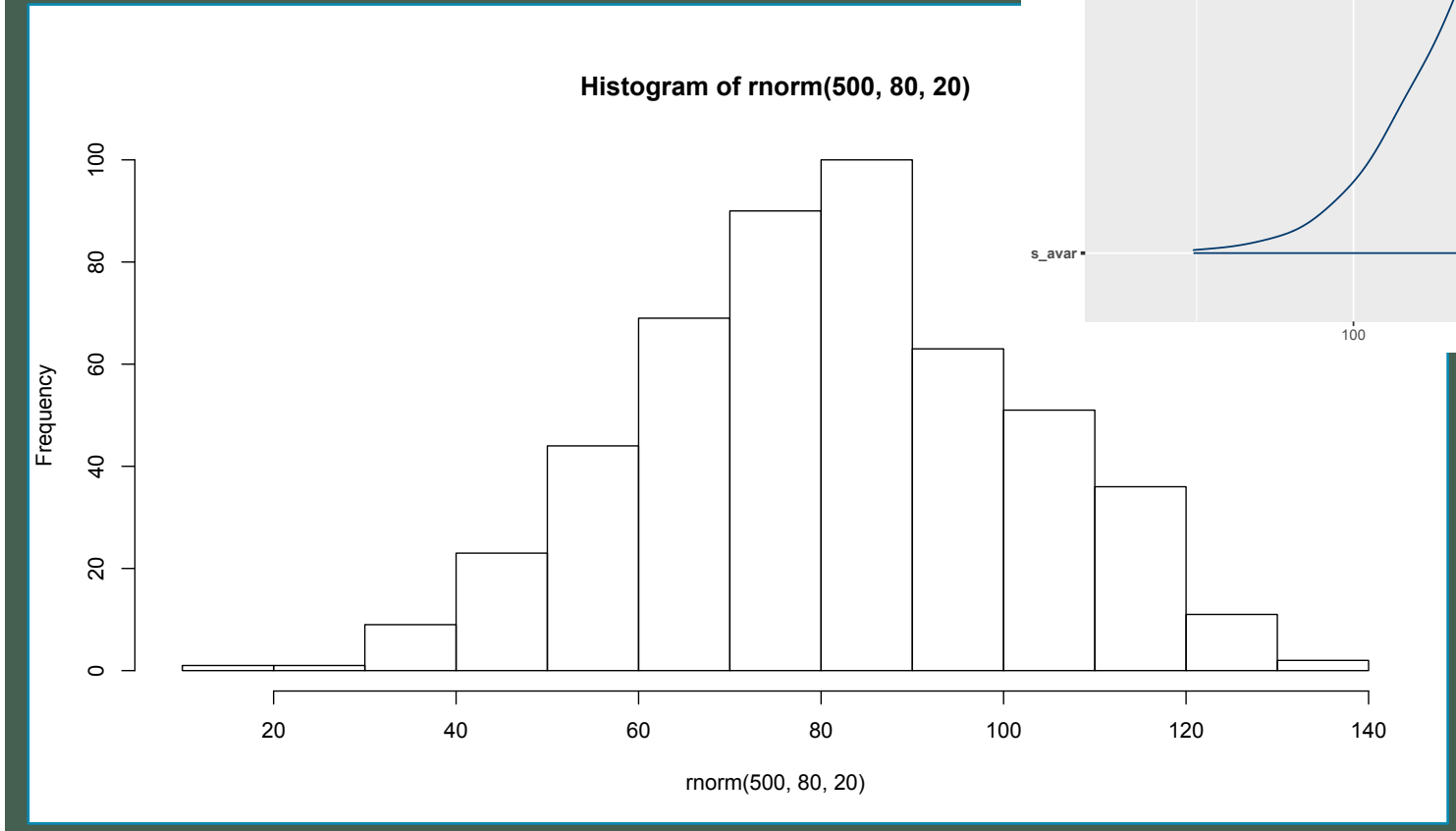


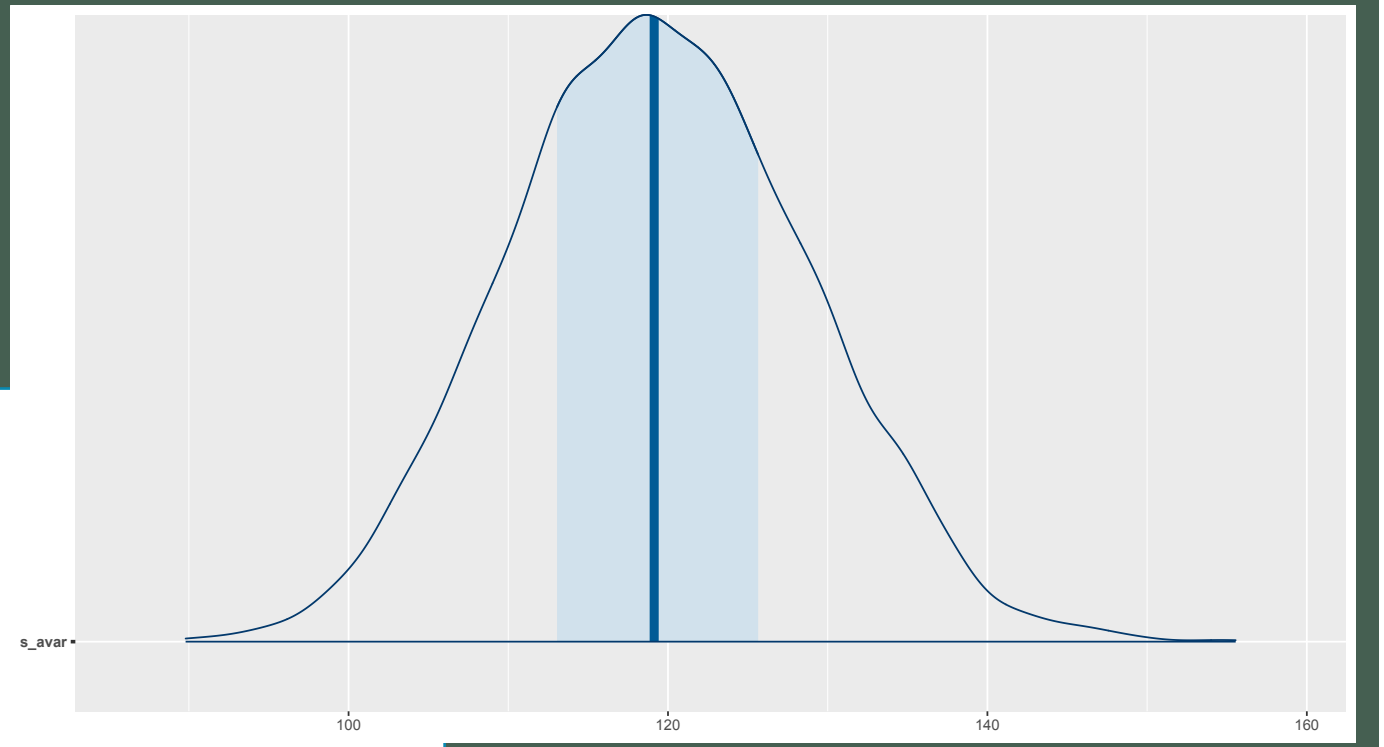
Mu_b: priors v posteriors



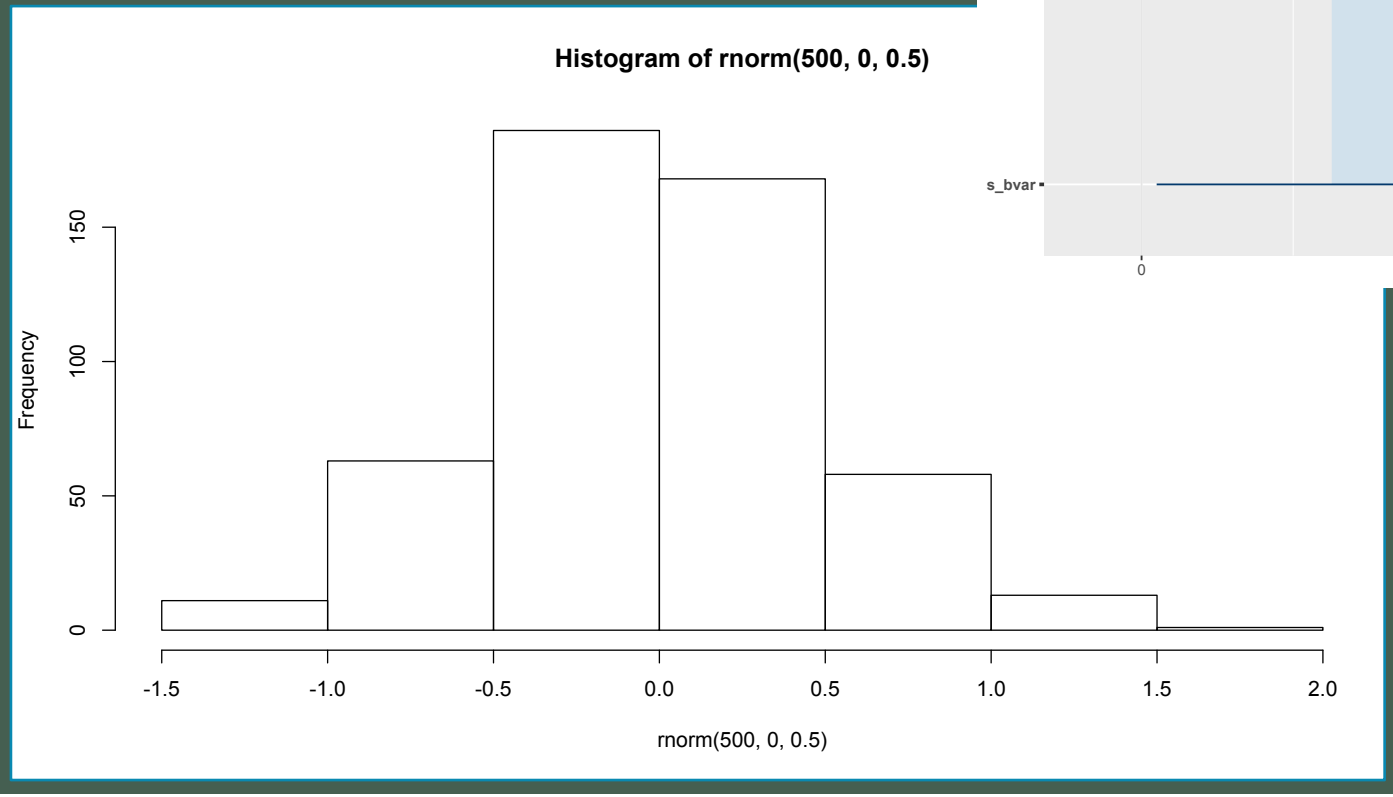


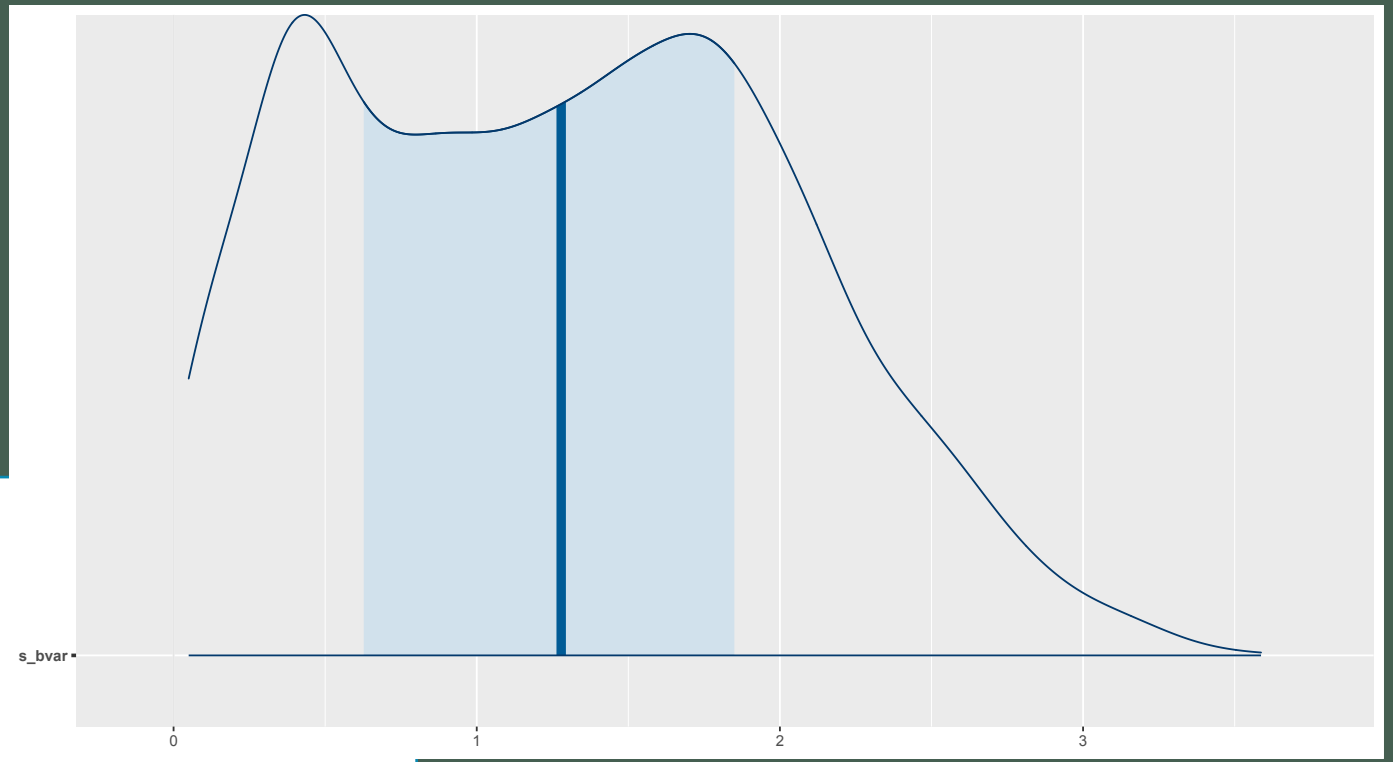
S_avar: priors v posteriors





s_bvar: priors v posteriors





Sigma_y: priors v posteriors