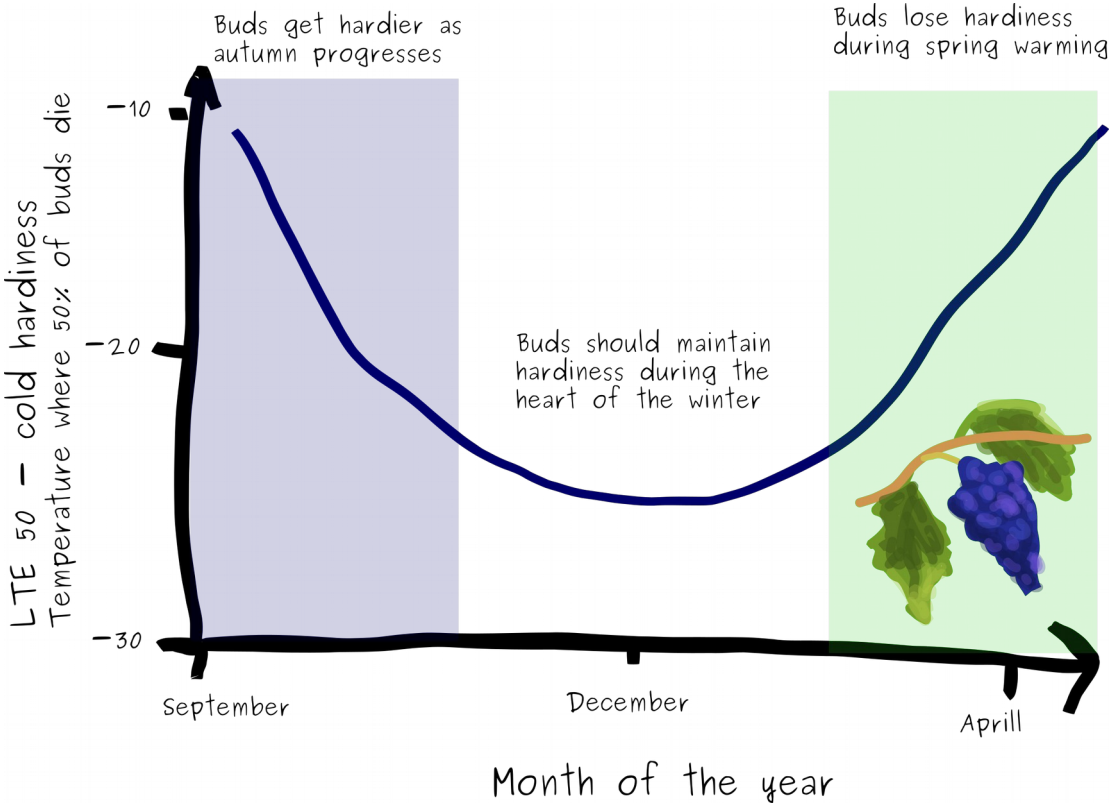
Winegrape hardiness update

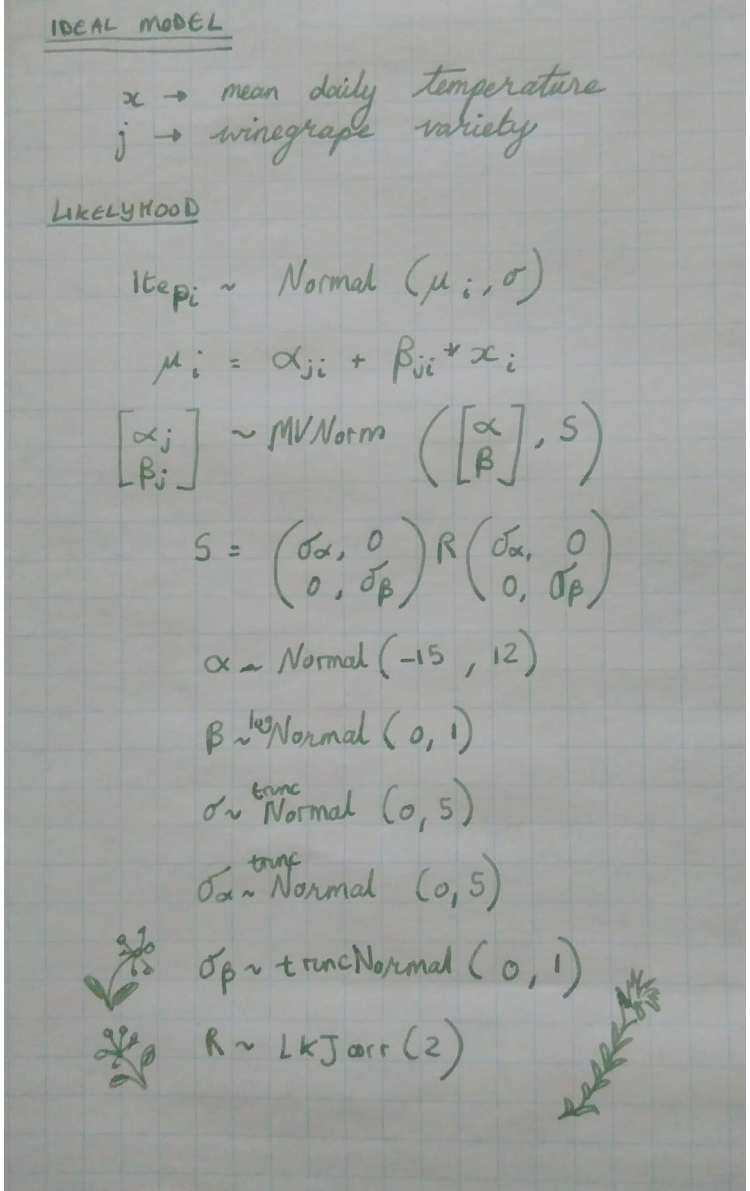
Random slopes for varieties



Faith Jones,
April 2020

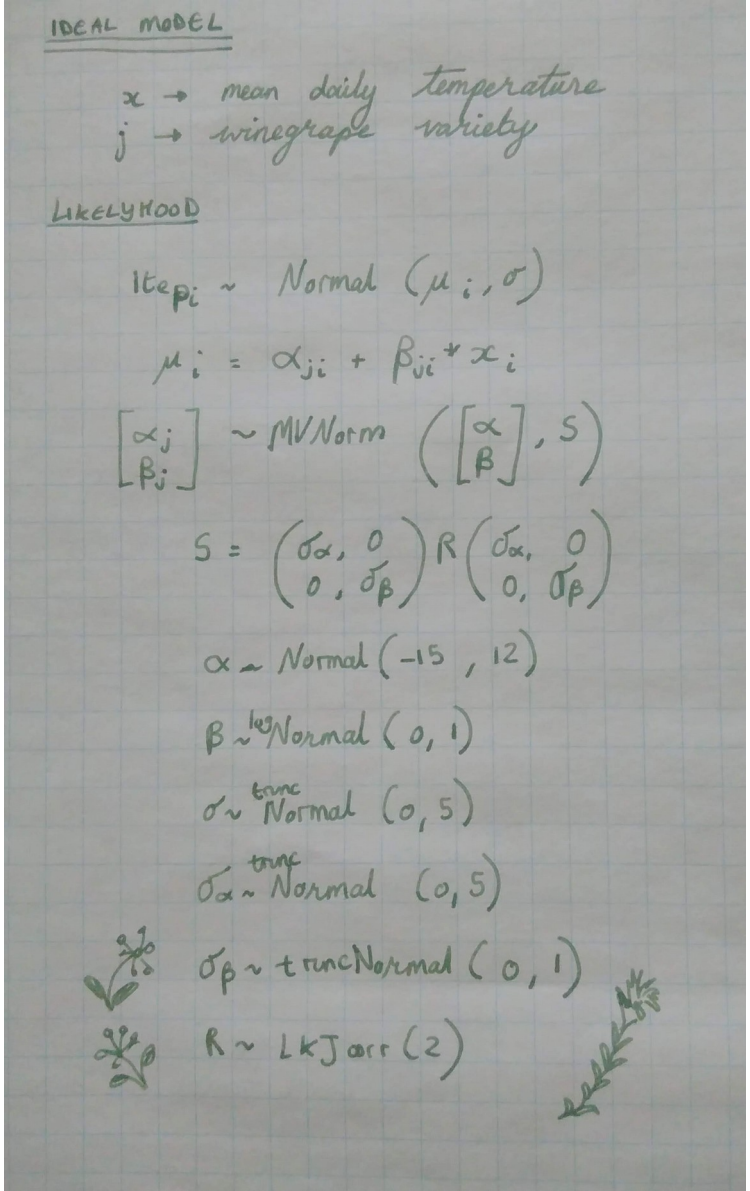
My question

- Can we predict winter hardiness from air temperature using a linear model?
- How does winter hardiness vary between winegrape varieties?
  - In terms of mean hardiness, do some varieties display greater variation (maybe more adaptable?)
  - Does the rate of change of hardiness change between varieties?



1. winter hardiness can be predicted using mean air temperature that day

2. Varieties will all have similar levels of variation in intercept LTE50 because all varieties are under the same phsiological constraints on adaptibility



1. winter hardiness can be predicted using mean air temperature that day

2. Varieties with a lower lte50 (temperature at which 50% of buds die) will have a steeper positive slope (sigma_beta)

This is because I assume a variety that gets hardier midwinter has to be able to get un-hardy again quickly so it is ready to go in the spring. Also soem suggestions that more winter hardy varieties will budbreak/lose hardiness with less warming in the spring than less hardy varieties.

IDEAL MODEL

$x \rightarrow$ mean daily temperature
$j \rightarrow$ winegrape variety

LIKELYHOOD

$$lte_{pi} \sim Normal(\mu_i, \sigma)$$

$$\mu_i = \alpha_{ji} + \beta_{ji} * x_i$$

$$\begin{bmatrix} \alpha_j \\ \beta_j \end{bmatrix} \sim MVNorm\left(\begin{bmatrix} \alpha \\ \beta \end{bmatrix}, S\right)$$

$$S = \begin{pmatrix} \sigma_\alpha & 0 \\ 0 & \sigma_\beta \end{pmatrix} R \begin{pmatrix} \sigma_\alpha & 0 \\ 0 & \sigma_\beta \end{pmatrix}$$

$$\alpha \sim Normal(-15, 12)$$

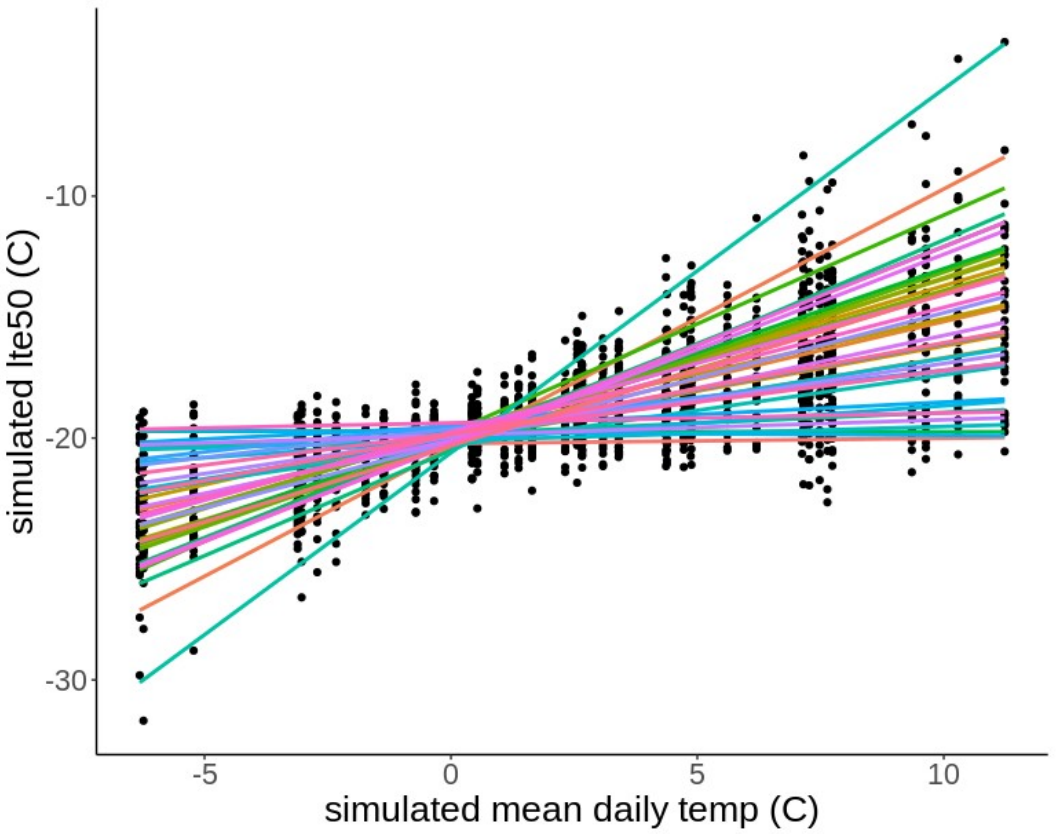
$$\beta \sim^{log} Normal(0, 1)$$

$$\sigma \sim^{trunc} Normal(0, 5)$$

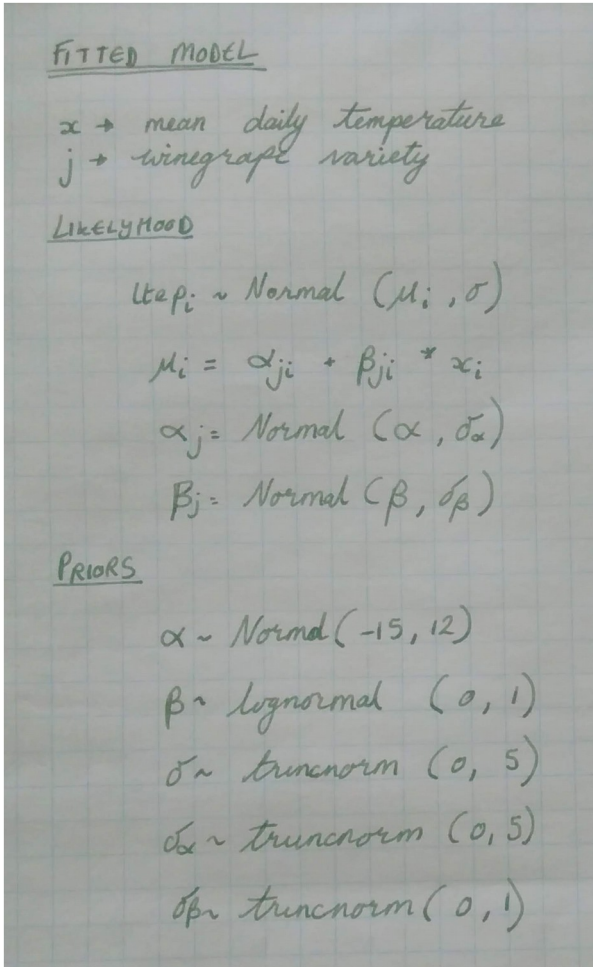
$$\sigma_\alpha \sim^{trunc} Normal(0, 5)$$

$$\sigma_\beta \sim truncNormal(0, 1)$$

$$R \sim LKJcorr(2)$$



Rho = -0.7



I couldn't get the ideal model to fit the real data.

Intead, I fitted this simpler model, which has the covarience structure removed.

I think I know why this model fitted when the covarience one didn't – there is very litte variation around the slope (sigma_beta). I think this was making it really hard for the model to work out the covariences.

FITTED MODEL

$x \rightarrow$ mean daily temperature
$j \rightarrow$ winegrape variety

LIKELYHOOD

$$LTE50_i \sim Normal(\mu_i, \sigma)$$

$$\mu_i = \alpha_{ji} + \beta_{ji} * x_i$$

$$\alpha_j = Normal(\alpha, \sigma_\alpha)$$

$$\beta_j = Normal(\beta, \sigma_\beta)$$

PRIORS

$$\alpha \sim Normal(-15, 12)$$

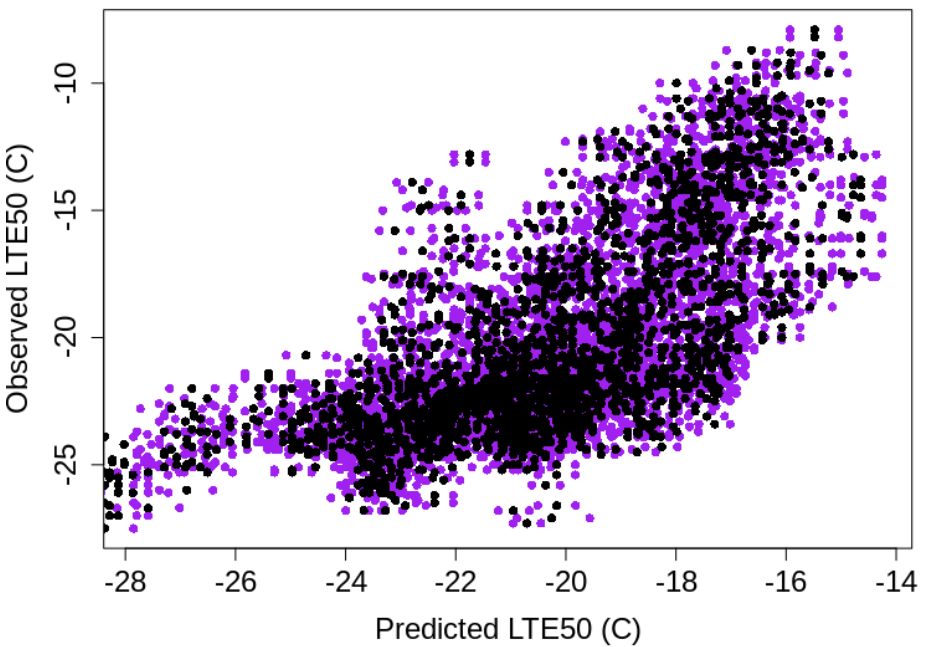
$$\beta \sim lognormal(0, 1)$$

$$\sigma \sim truncnorm(0, 5)$$

$$\sigma_\alpha \sim truncnorm(0, 5)$$

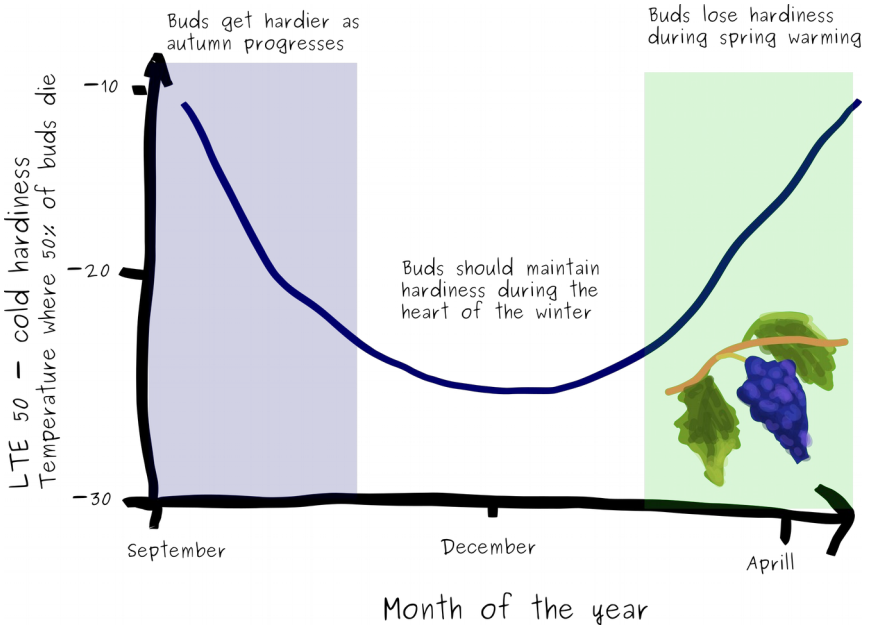
$$\sigma_\beta \sim truncnorm(0, 1)$$

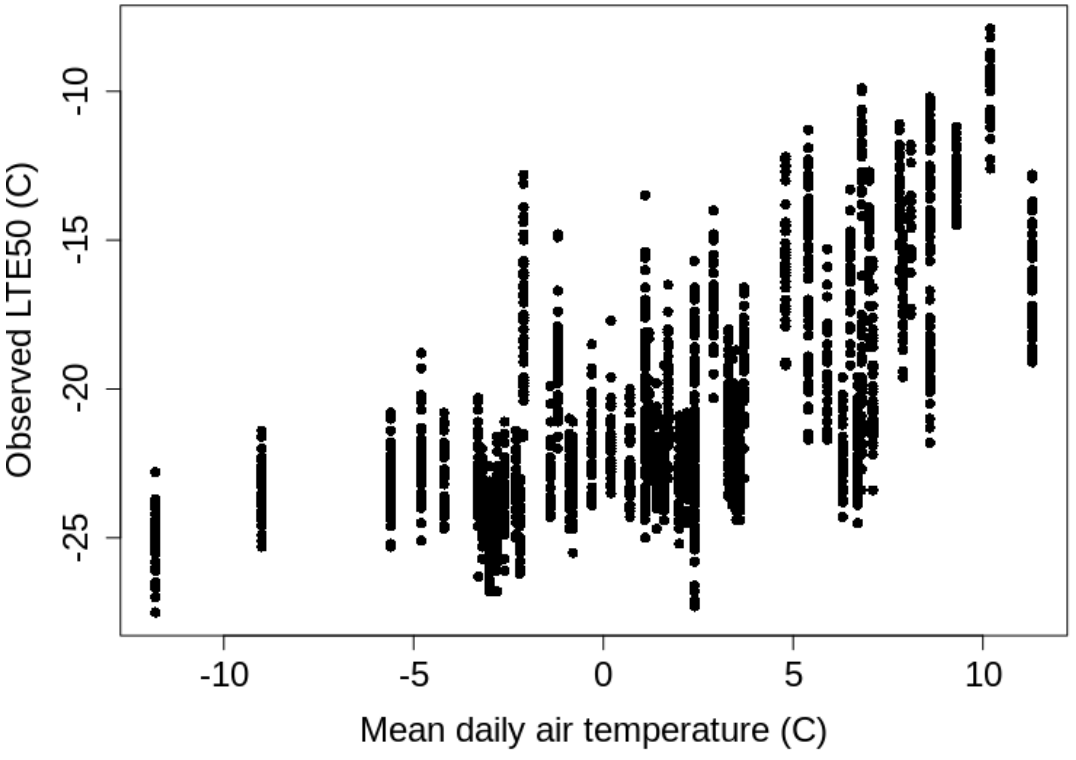
Predicted values againts observed values



Hypotheses interpretation

- 1. winter hardiness can be predicted using mean air temperature that day
  - Kind of, but nop very accurately, especially for low air temperatures. My model generally overestimates winegrape winter hardiness at very low temperatures. Probably because there is a maximum hardiness that the model doesnt know about
  - Also maybe a problem that the model doesnt know the difference between autumn acclimation and spring deacclimation


Buds get hardier as autumn progresses
Buds lose hardiness during spring warming
Buds should maintain hardiness during the heart of the winter
LTE 50 – cold hardiness
Temperature where 50% of buds die
−10
−20
−30
September
December
Aprill
Month of the year


Observed LTE50 (C)
-10
-15
-20
-25
-10
-5
0
5
10
Mean daily air temperature (C)

Hypotheses interpretation

2. How does winter hardiness vary between winegrape varieties?

FITTED MODEL

$x \rightarrow$ mean daily temperature
$j \rightarrow$ winegrape variety

LIKELYHOOD

$$\text{ltep}_i \sim \text{Normal}(\mu_i, \sigma)$$

$$\mu_i = \alpha_{ji} + \beta_{ji} * x_i$$

$$\alpha_j = \text{Normal}(\alpha, \sigma_\alpha)$$

$$\beta_j = \text{Normal}(\beta, \sigma_\beta)$$

PRIORS

$$\alpha \sim \text{Normal}(-15, 12)$$

$$\beta \sim \text{lognormal}(0, 1)$$

$$\sigma \sim \text{truncnorm}(0, 5)$$

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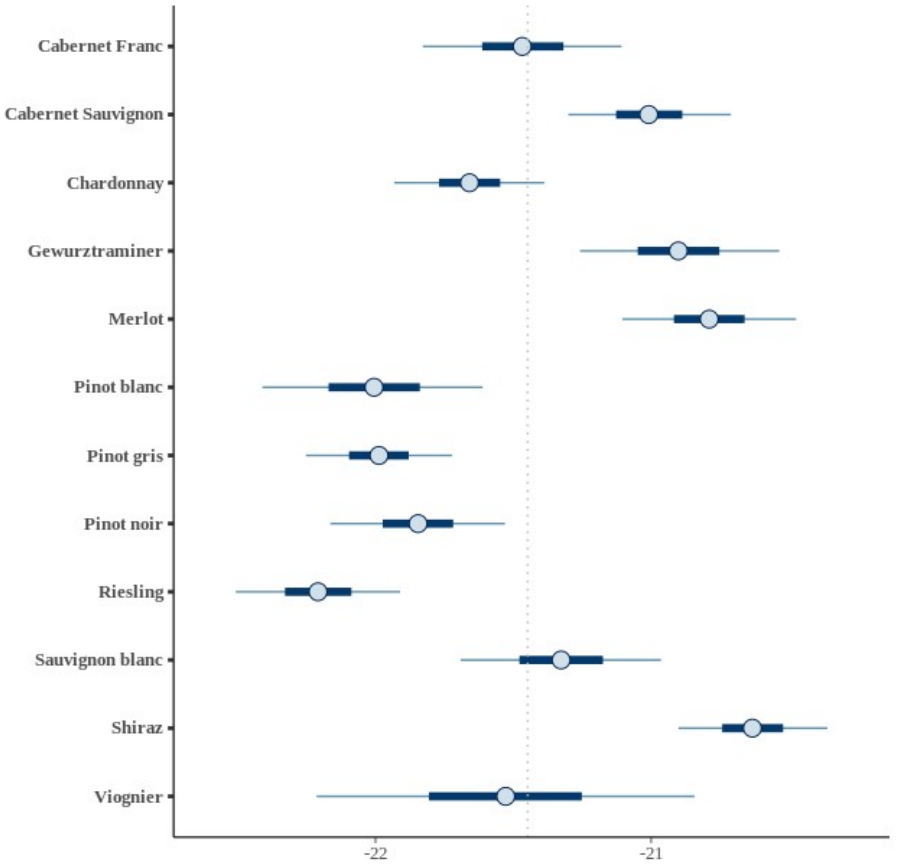
Variety intercepts



Hypotheses interpretation

2. How does winter hardiness vary between winegrape varieties?

- There are differences between varieties in terms of their hardiness at 0 degrees C (intercept value) and so I assume their overall hardiness.
- No obvious differences in the variation around each variety

FITTED MODEL

$x \rightarrow$ mean daily temperature
$j \rightarrow$ winegrape variety

LIKELYHOOD

$$\text{ltep}_i \sim \text{Normal}(\mu_i, \sigma)$$

$$\mu_i = \alpha_{ji} + \beta_{ji} * x_i$$

$$\alpha_j = \text{Normal}(\alpha, \sigma_\alpha)$$

$$\beta_j = \text{Normal}(\beta, \sigma_\beta)$$

PRIORS

$$\alpha \sim \text{Normal}(-15, 12)$$

$$\beta \sim \text{lognormal}(0, 1)$$

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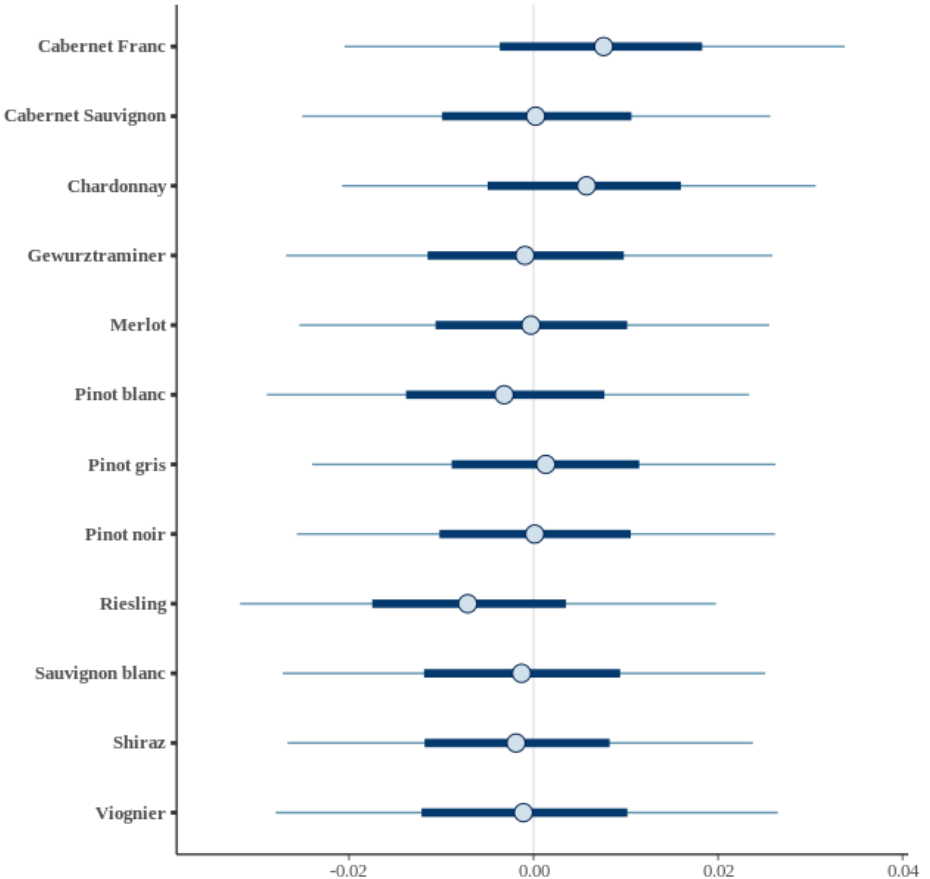
Variety slopes



Hypotheses interpretation

2. How does winter hardiness vary between winegrape varieties?

- There are differences between varietiy interecpts, but no varietiy looks particuarly plastic in terms of hardiness
- But I found no evidence of differences in rates of change of hardiness
- What does that mean for the physiology of winegrape hardiness?

Next Steps

- Need more information in the model to help it predict hardiness better
  - Different slopes of acclimation and deacclimation? But how to chose when to change from one to the other
  - Some non linear transformation to a maximum hardiness? But how to select maximum hardiness?