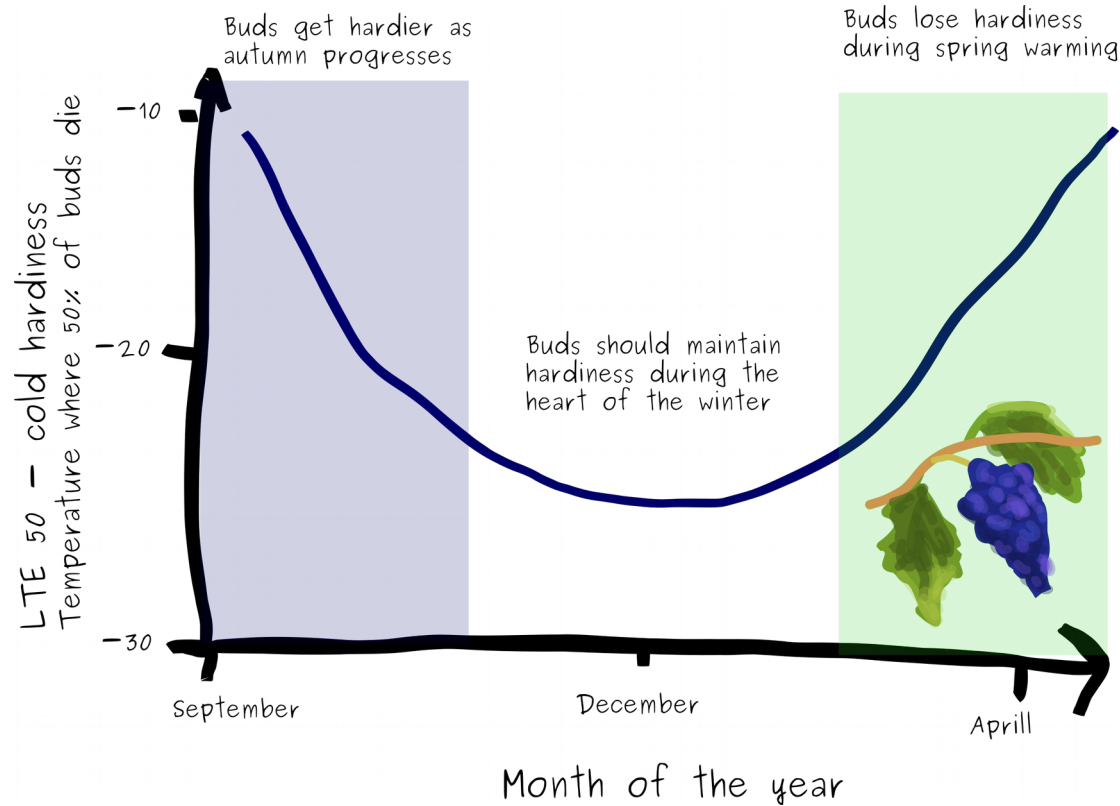


# Winegrape hardiness update

## 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?

### IDEAL MODEL

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

### LIKELIHOOD

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

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

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

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

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

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

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

$$\sigma_\alpha \sim \text{truncNormal}(0, 5)$$

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

$$R \sim \text{LKJarr}(2)$$

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 physiological constraints on adaptability

slopeVarietyCov.stan

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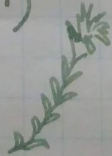
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1. winter hardiness can be predicted using mean air temperature that day

2. Varieties with a lower  $lte_{50}$  (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.

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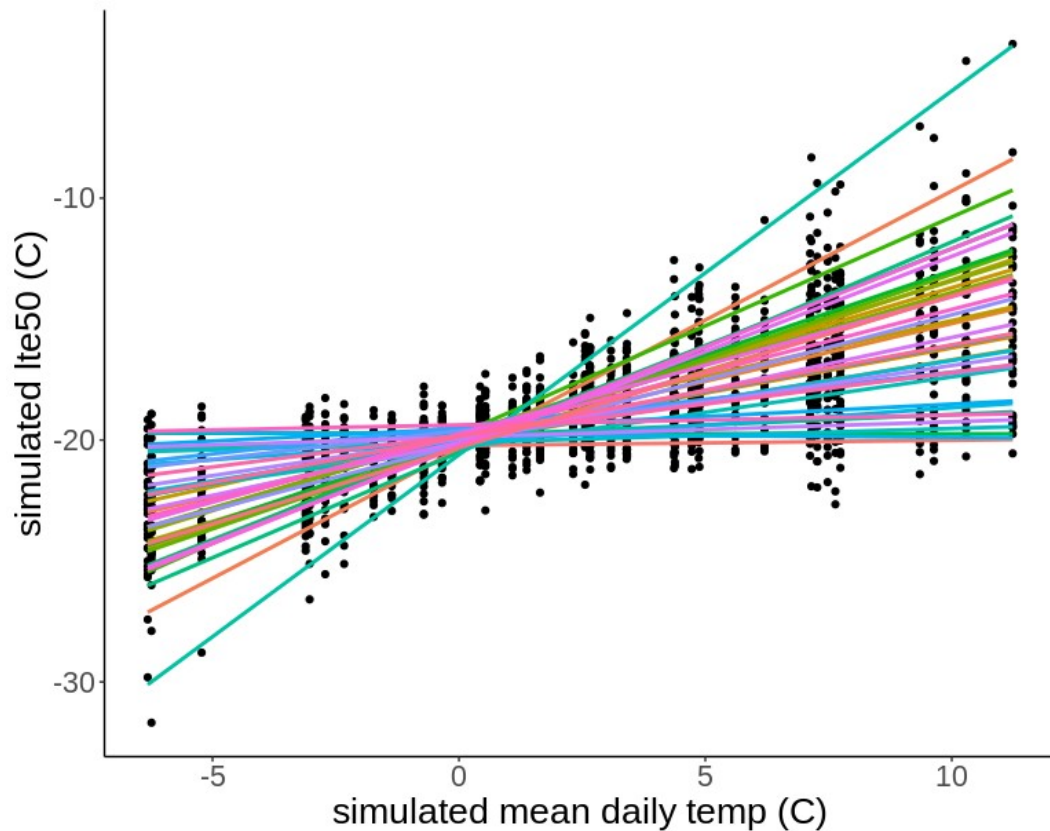
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Rho = -0.7



### FITTED MODEL

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 $j$  → winegrape variety

### LIKELIHOOD

$$l_{tep_i} \sim \text{Normal}(\mu_i, \sigma)$$

$$\mu_i = \alpha_j + \beta_j * x_i$$

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### PRIORS

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

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

I think I know why this model fitted when the covariance 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.

nonCentre\_slopeVariety\_beta.stan

### FITTED MODEL

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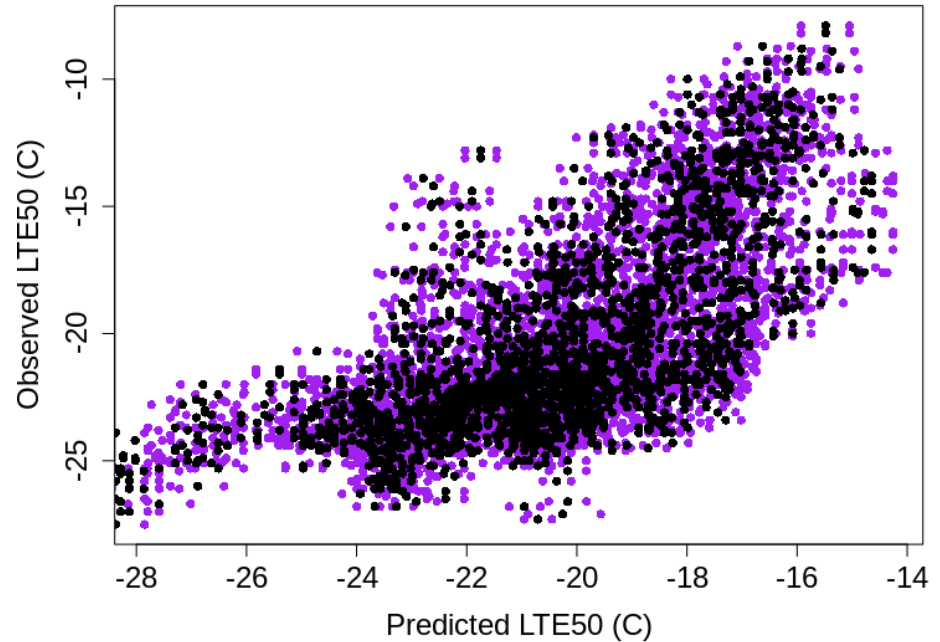
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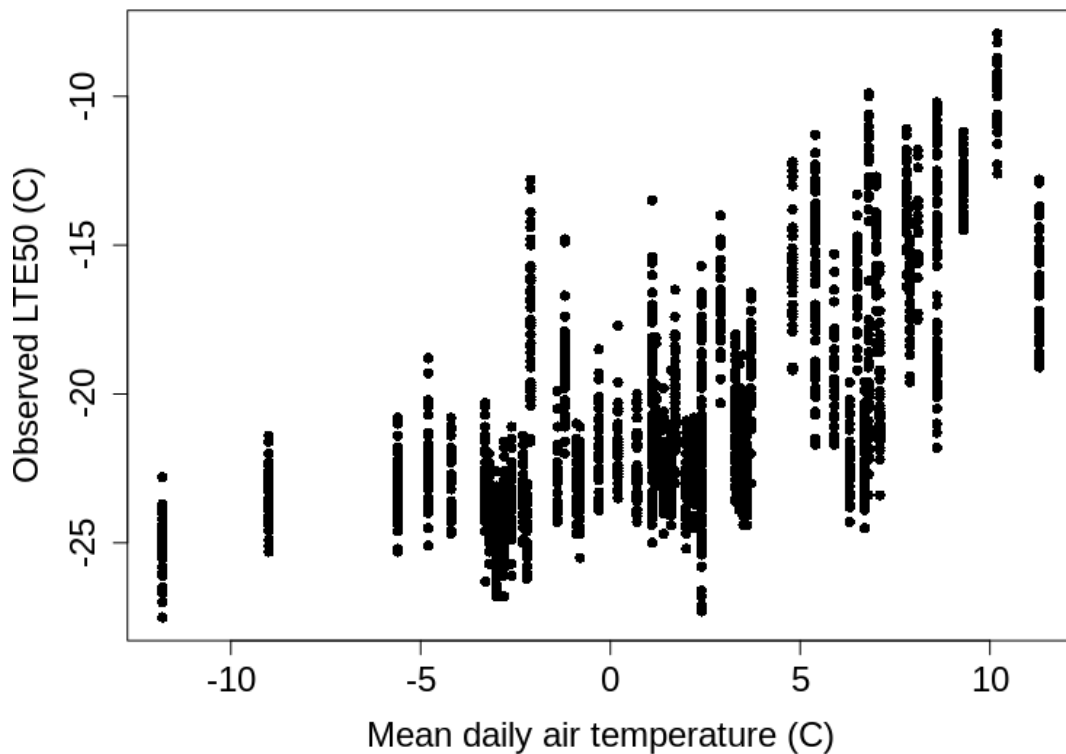
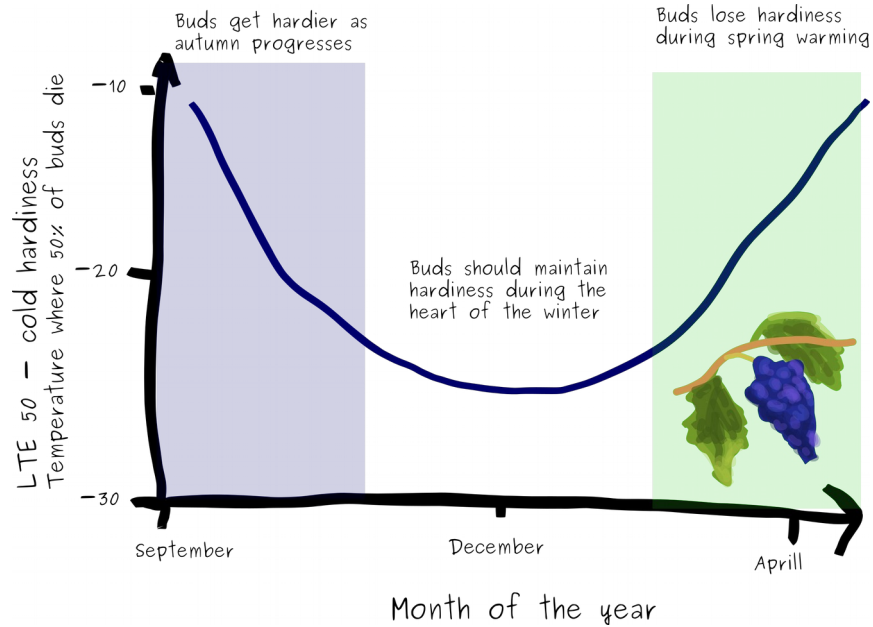
Predicted values againsts observed values



# Hypotheses interpretation

- 1. winter hardiness can be predicted using mean air temperature that day
  - Kind of, but not 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 doesn't know about
  - Also maybe a problem that the model doesn't know the difference between autumn acclimation and spring deacclimation





# Hypotheses interpretation

2. How does winter hardiness vary between winegrape varieties?

### FITTED MODEL

$x \rightarrow$  mean daily temperature  
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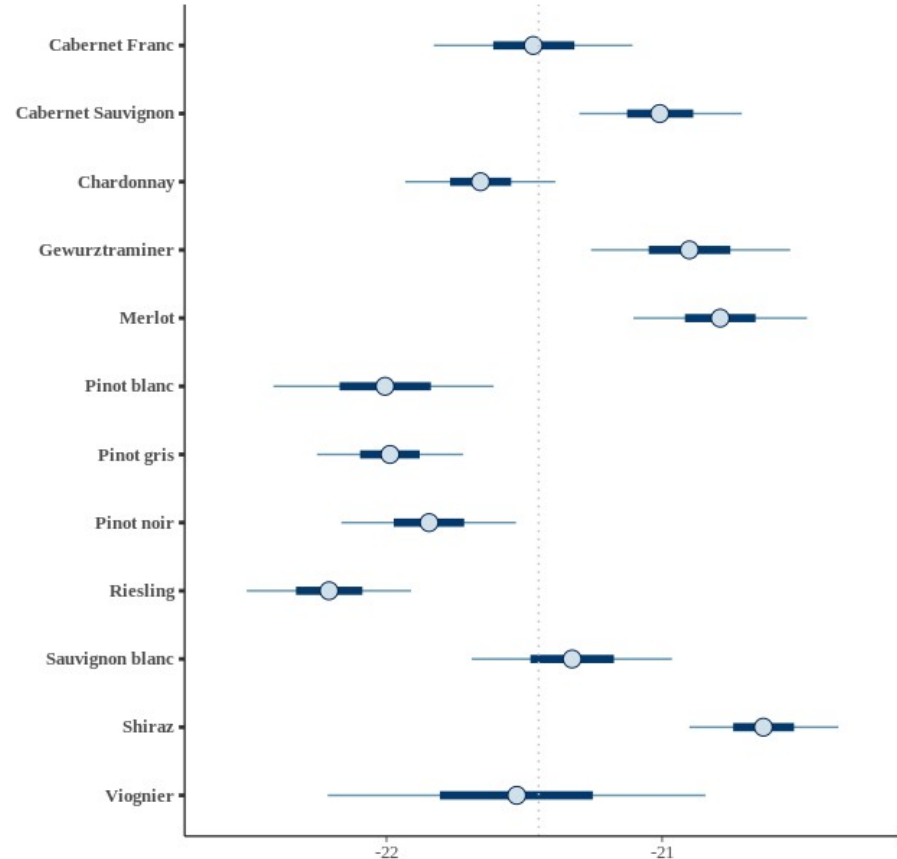
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## Variety intercepts



# 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

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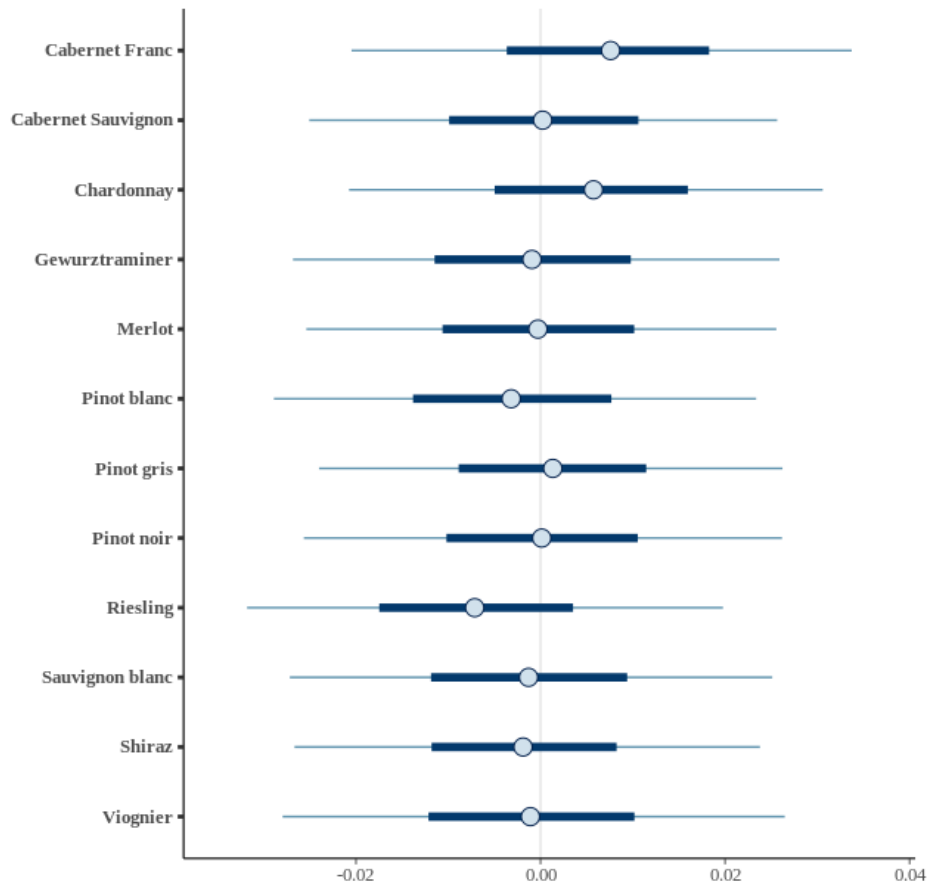
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## Variety slopes



# Hypotheses interpretation

2. How does winter hardiness vary between winegrape varieties?

- There are differences between variety intercepts, but no variety looks particularly 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 hardness better
  - Different slopes of acclimation and deacclimation?  
But how to choose when to change from one to the other
  - Some non linear transformation to a maximum hardness? But how to select maximum hardness?