

Prediction of tree growth under climate change scenarios using tree rings of *Pinus pinea* L. in Spain

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1 Introduction

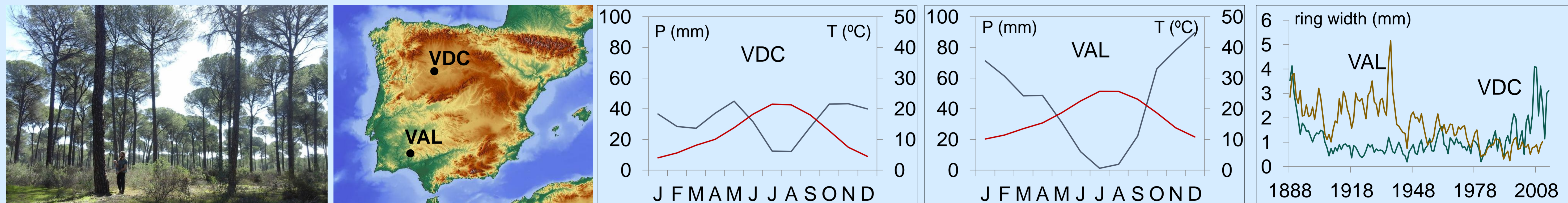
2 Research questions

How can we model tree growth-climate relationships to predict forest growth trends under climate change scenarios?
 What climate variables should be considered when building models for Iberian Mediterranean forests?

Predicting trends of Mediterranean tree growth under warmer climate in the Iberian Peninsula is important to implement adaptive management systems in forestry. Tree-ring series reflect effects of climate variations on growth and thus permit to build models for long-term predictions. Building models can be accomplished by classic dendroclimatological approach, but mixed models can be also applied and merit investigation.

3 Materials & methods

Tree-ring chronologies from two managed stands of adult *Pinus pinea* trees with same macroclimate (Mediterranean) and different pluviometric regimes.



Procedure:

1. Correlations between standardized tree-ring chronologies and climate data on different time scales
2. Selection of strongest significant correlations
3. Generation of all possible combinations of climate variables with strongest significant correlations
4. Two tree-growth models for each combination of climate variables: linear regression (LR) and generalized additive mixed model (GAMM)
5. Selection of the best models (adjusted R-squared, mean square error, variance inflation factor, condition number, AIC, cross-validation)

4 Results

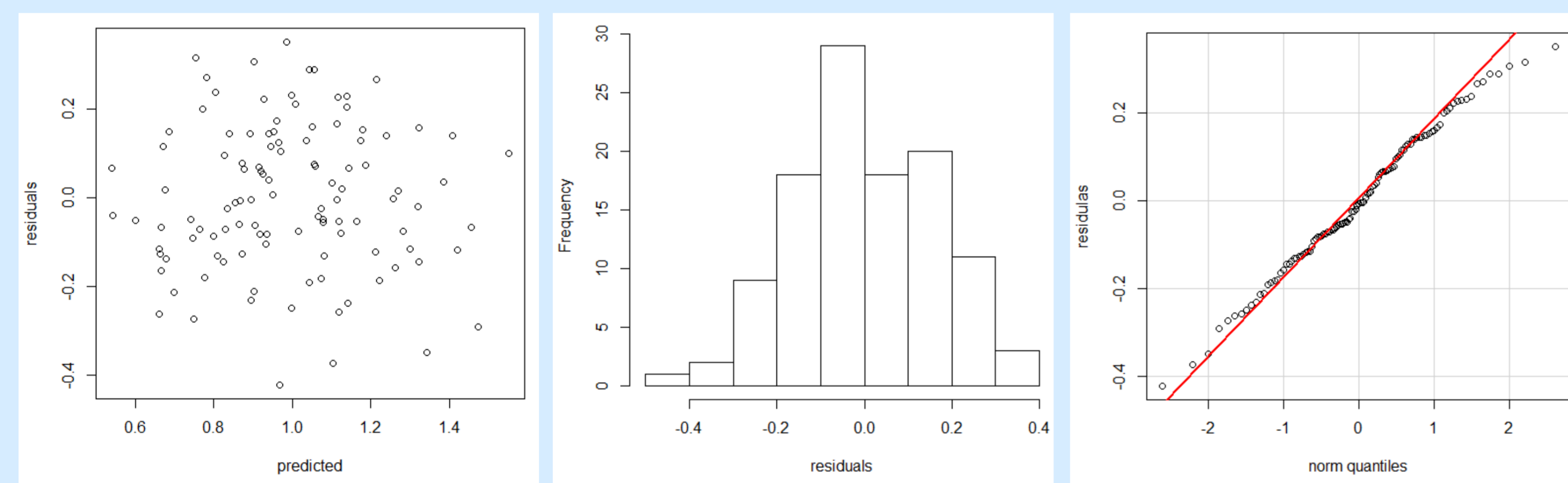
VDC

The best model included:

sum of precipitation ("p") from Sep. of the previous year to current May;
 min. temperatures ("tmi") averaged from previous Nov. to current Feb.;
 max. temperatures ("tma") averaged from current Apr. to Jun.

R code for LINEAR REGRESSION:

```
lm ( VDC ~ p_prevSep_May + tmi_prevNov_Feb + tma_Apr_Jun)
```



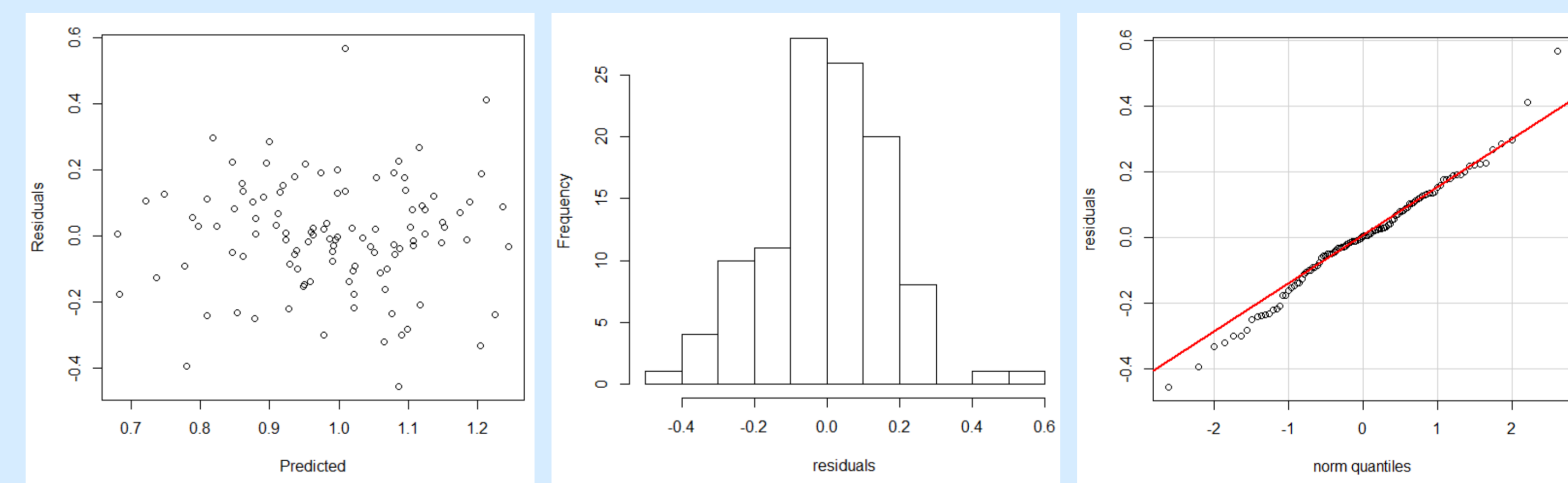
VAL

The best model included:

sum of precipitation ("p") from previous Oct. to current Oct.;
 min. temperatures ("tmi") averaged from current Jan. to Feb.

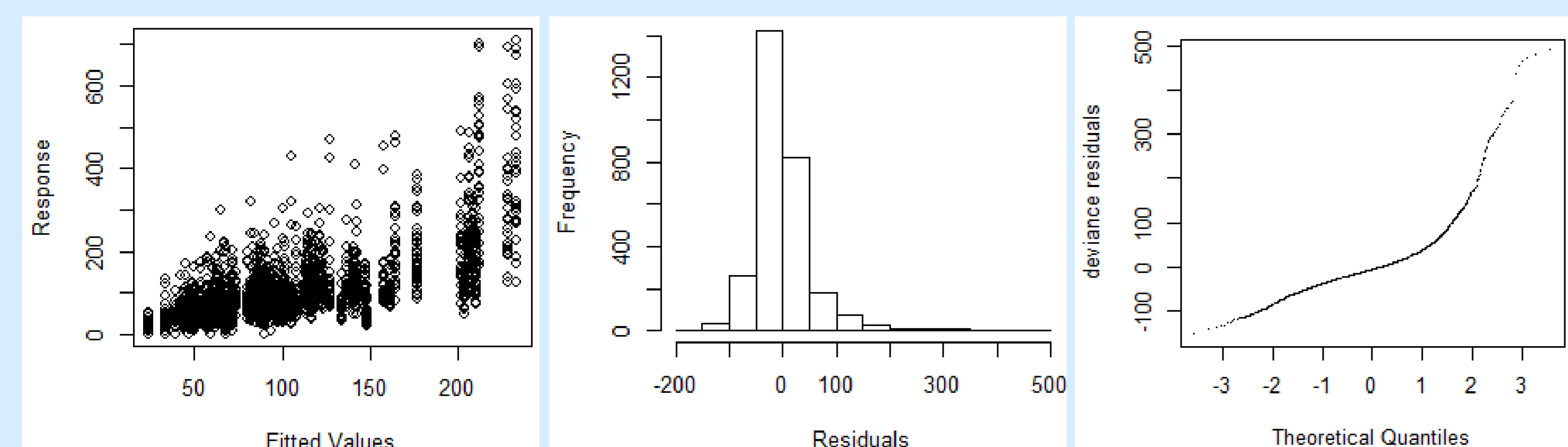
R code for LINEAR REGRESSION

```
lm ( VAL ~ p_prevOct_Oct + tmi_Jan_Feb)
```



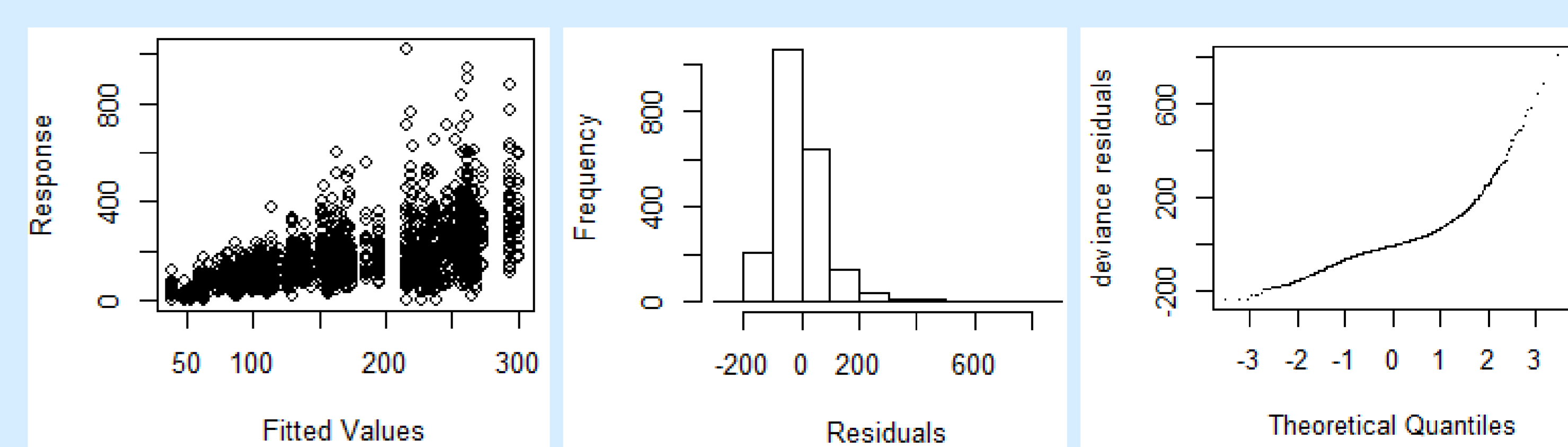
R code for GENERALIZED ADDITIVE MIXED MODEL :

```
gamm(VDC~s(year,k=10,bs='cr')+p_prevSep_May+tmi_prevNov_Feb+tma_Apr_Jun,random=list(tree=~1),correlation=corAR1(),family=gaussian())
```



R code for GENERALIZED ADDITIVE MIXED MODEL :

```
gamm (VAL ~ s(year, k=10, bs='cr') + prec_prevOct_Oct + tmin_Jan_Feb, random=list(tree=~1), correlation=corAR1(), family=gaussian())
```



5 Concluding remarks

The different growth response to spring/summer (Apr_Jun) temperatures reflect the spatial variability of climate (Natalini et al. 2016, *Dendrochronologia* 40, pp. 72-84). LR was suitable to model growth-climate relationships, following classical dendroclimatological approaches. GAMM include smooth terms, so do not need previous detrending of tree-ring series like in dendroclimatological approaches. GAMM consider the random effects of individual trees, without averaging the individual tree-ring chronologies (like in dendroclimatological approaches) and thus reducing the potential loss of ecological information deriving from growth variability among trees. However, the preliminary results presented here indicate the need for further tests of GAMM to model growth trends in relation to climatic variations.