Supplementary Materials

Figure S1 - R^2 and AIC values of the BRIN Daily model obtained for all fitted and average models, grapevine varieties and starting dates. The symbols (points and triangles) show the model results at two starting dates (in this example t_0 = -121 and -152 DOY), while the two colours represent fitting (red) and validation (blue) procedure, respectively. The filled symbols constitute the R^2 and AIC values of the models obtained by the selected HP parameter sets, while the dashed (fitting) and dotted (validation) lines depict the average R^2 and AIC values for both starting dates (in this example orange line = -121 DOY and green line = -152 DOY). The boxplots represent the R^2 and AIC values distribution for HP (orange and light blue: HP model application on all validation sub-samples for t_0 = -121 and t_0 = -152 DOY, respectively) and AV (boxplot in the shaded area, orange and light blue: AV application on all validation sub-samples for t_0 = -121 and t_0 = -152 DOY, respectively). The outliers represent all values out of the 1.5*InterQuartile Range (IQR) of the boxplot.

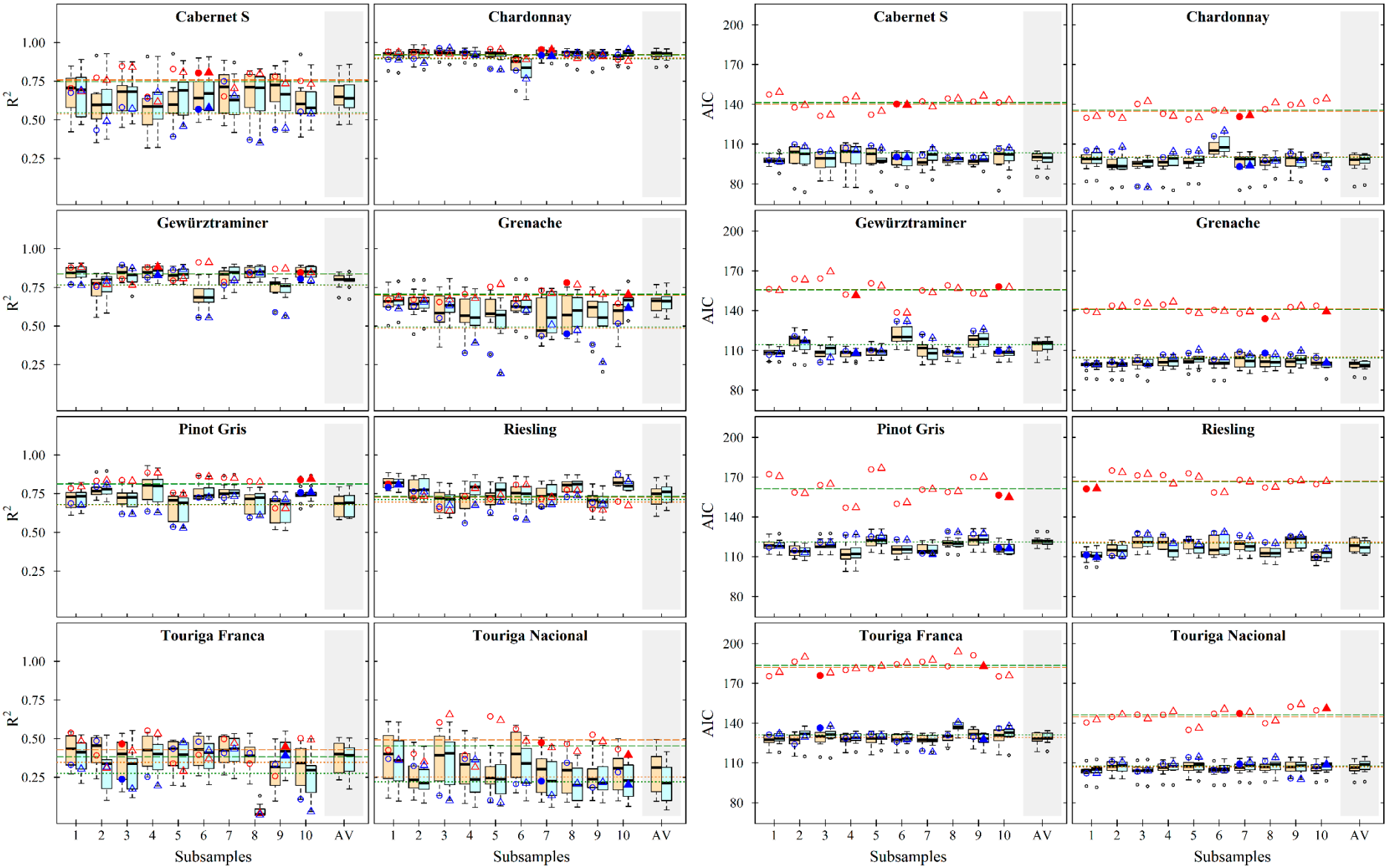

Cabernet S
Chardonnay
Gewürztraminer
Grenache
Pinot Gris
Riesling
Touriga Franca
Touriga Nacional
R2
AIC
1.00
0.75
0.50
0.25
200
170
140
110
80
1 2 3 4 5 6 7 8 9 10 AV
Subsamples

Figure S2. R^2 and AIC values of the BRIN Hourly model obtained for all fitted and average models, grapevine varieties and starting dates. The symbols (points and triangles) show the model results at two starting dates (in this example t_0 = -121 and -152 DOY), while the two colours represent fitting (red) and validation (blue) procedure, respectively. The filled symbols constitute the R^2 and AIC values of the models obtained by the selected HP parameter sets, while the dashed (fitting) and dotted (validation) lines depict the average R^2 and AIC values for both starting dates (in this example orange line = -121 DOY and green line = -152 DOY). The boxplots represent the R^2 and AIC values distribution for HP (orange and light blue: HP model application on all validation sub-samples for t_0 = -121 and t_0 = -152 DOY, respectively) and AV (boxplot in the shaded area, orange and light blue: AV application on all validation sub-samples for t_0 = -121 and t_0 = -152 DOY, respectively). The outliers represent all values out of the 1.5*InterQuartile Range (IQR) of the boxplot.

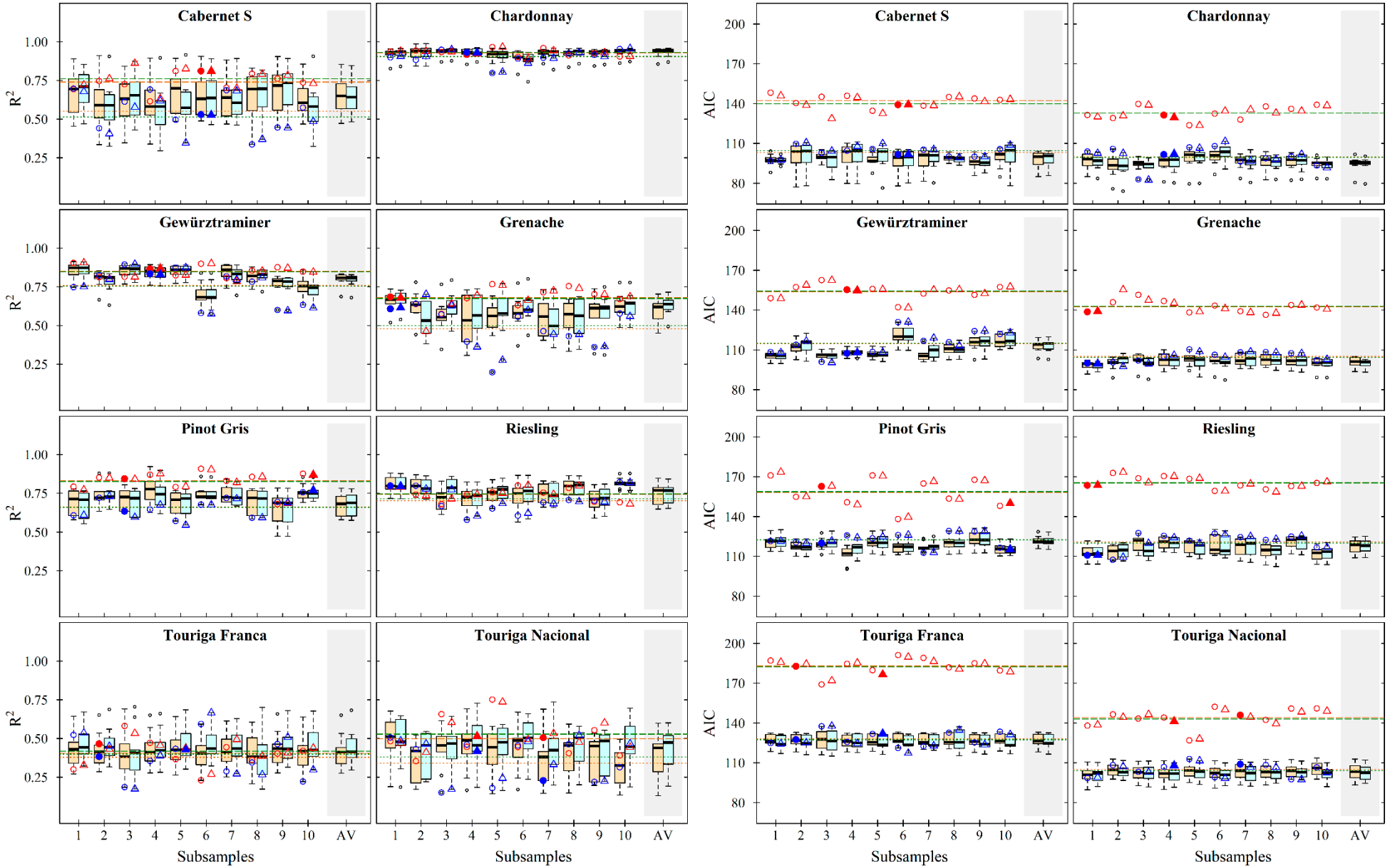
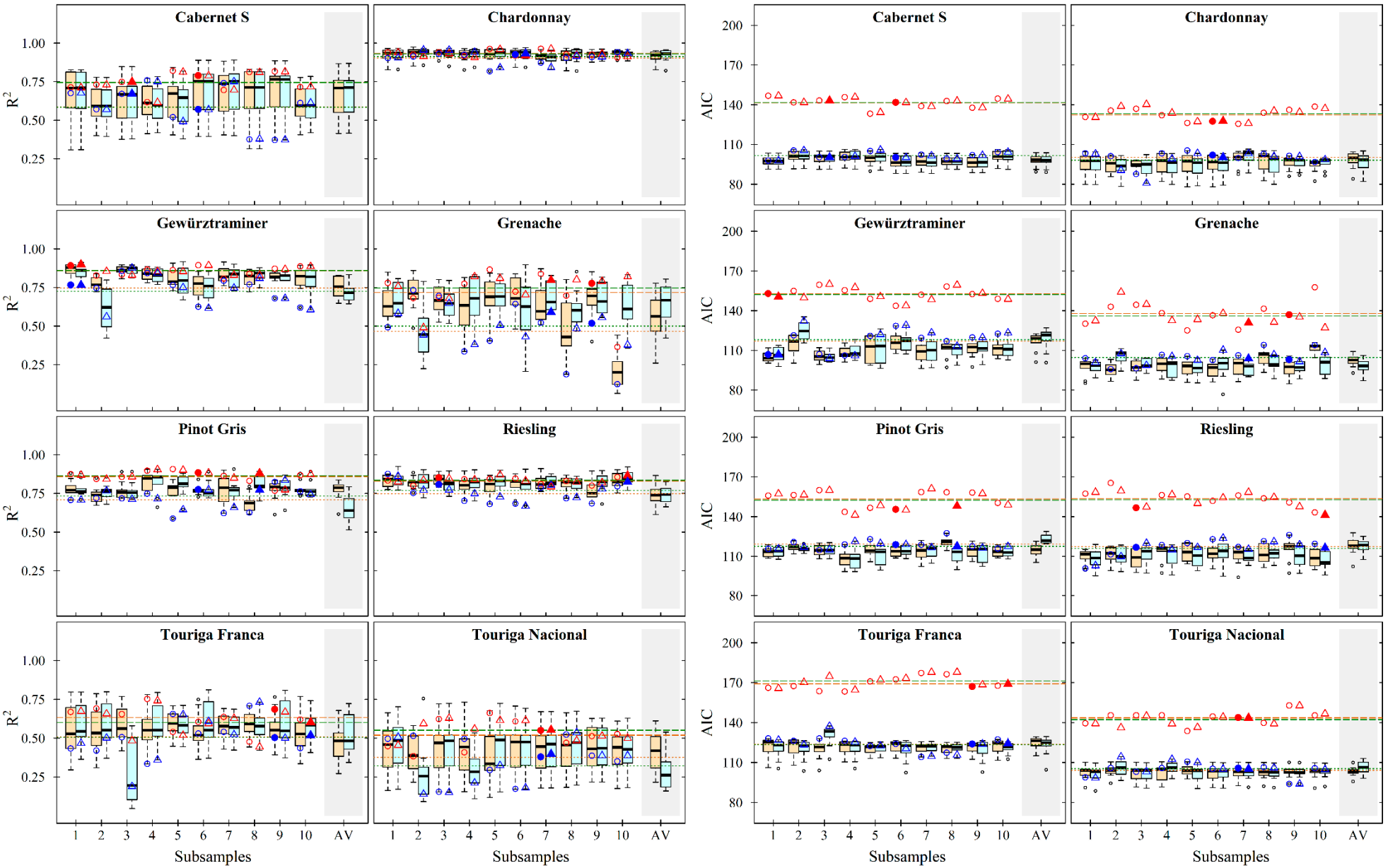

Cabernet S
Chardonnay
Gewürztraminer
Grenache
Pinot Gris
Riesling
Touriga Franca
Touriga Nacional
R2
AIC
1.00
0.75
0.50
0.25
200
170
140
110
80
1 2 3 4 5 6 7 8 9 10 AV
Subsamples

Figure S3 - R^2 and AIC values of the UNICHILL model obtained for all fitted and average models, grapevine varieties and starting dates. The symbols (points and triangles) show the model results at two starting dates (in this example t_0 = -121 and -152 DOY), while the two colours represent fitting (red) and validation (blue) procedure, respectively. The filled symbols constitute the R^2 and AIC values of the models obtained by the selected HP parameter sets, while the dashed (fitting) and dotted (validation) lines depict the average R^2 and AIC values for both starting dates (in this example orange line = -121 DOY and green line = -152 DOY). The boxplots represent the R^2 and AIC values distribution for HP (orange and light blue: HP model application on all validation sub-samples for t_0 = -121 and t_0 = -152 DOY, respectively) and AV (boxplot in the shaded area, orange and light blue: AV application on all validation sub-samples for t_0 = -121 and t_0 = -152 DOY, respectively). The outliers represent all values out of the 1.5*InterQuartile Range (IQR) of the boxplot.


Cabernet S
Chardonnay
Gewürztraminer
Grenache
Pinot Gris
Riesling
Touriga Franca
Touriga Nacional
R2
AIC
1.00
0.75
0.50
0.25
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170
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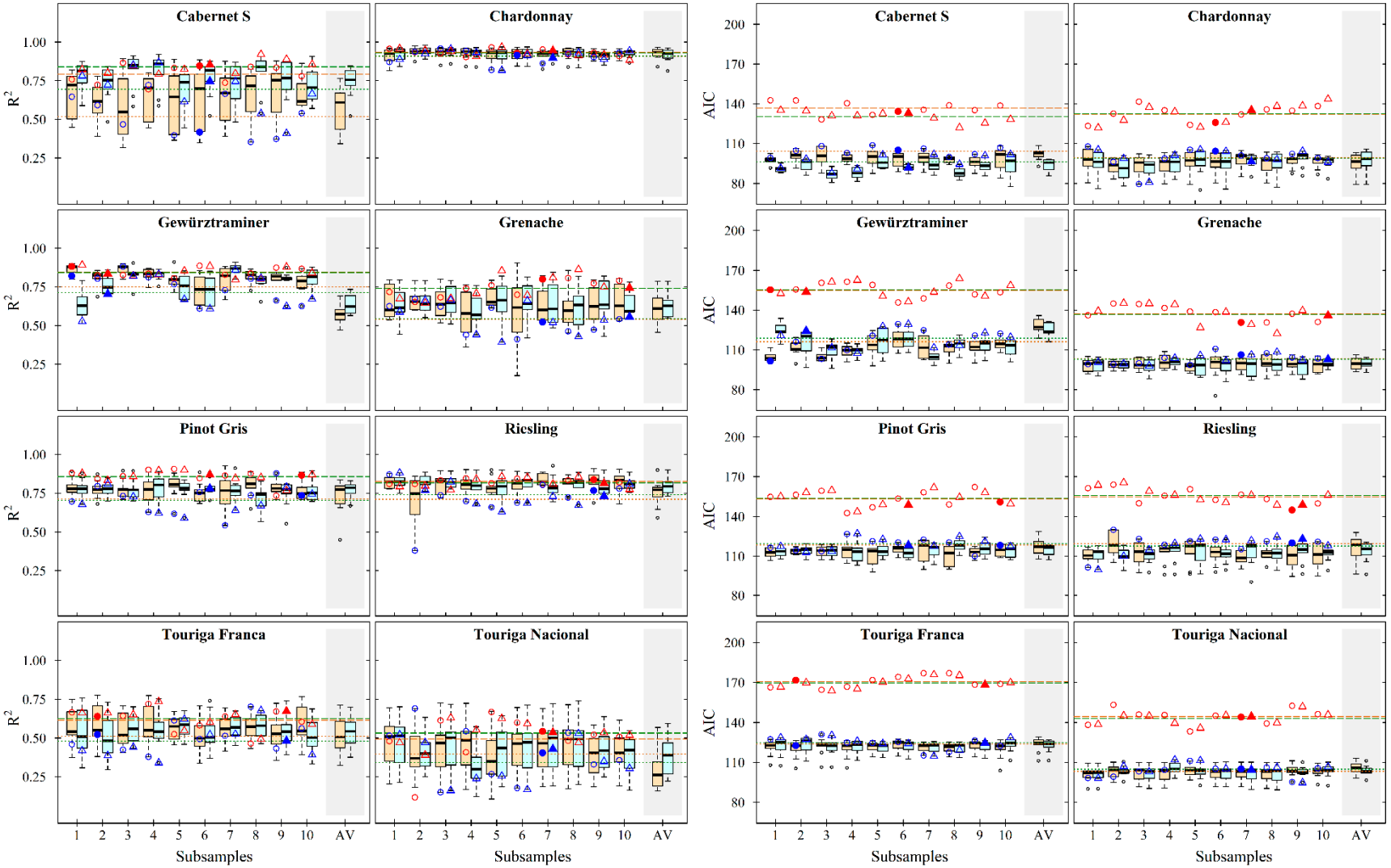
110
80
1 2 3 4 5 6 7 8 9 10 AV
Subsamples

Figura S4 - R^2 and AIC values of the UNIFIED model obtained for all fitted and average models, grapevine varieties and starting dates. The symbols (points and triangles) show the model results at two starting dates (in this example t_0 = -121 and -152 DOY), while the two colours represent fitting (red) and validation (blue) procedure, respectively. The filled symbols constitute the R^2 and AIC values of the models obtained by the selected HP parameter sets, while the dashed (fitting) and dotted (validation) lines depict the average R^2 and AIC values for both starting dates (in this example orange line = -121 DOY and green line = -152 DOY). The boxplots represent the R^2 and AIC values distribution for HP (orange and light blue: HP model application on all validation sub-samples for t_0 = -121 and t_0 = -152 DOY, respectively) and AV (boxplot in the shaded area, orange and light blue: AV application on all validation sub-samples for t_0 = -121 and t_0 = -152 DOY, respectively). The outliers represent all values out of the 1.5*InterQuartile Range (IQR) of the boxplot.


Cabernet S
Chardonnay
Gewürztraminer
Grenache
Pinot Gris
Riesling
Touriga Franca
Touriga Nacional
R2
AIC
1.00
0.75
0.50
0.25
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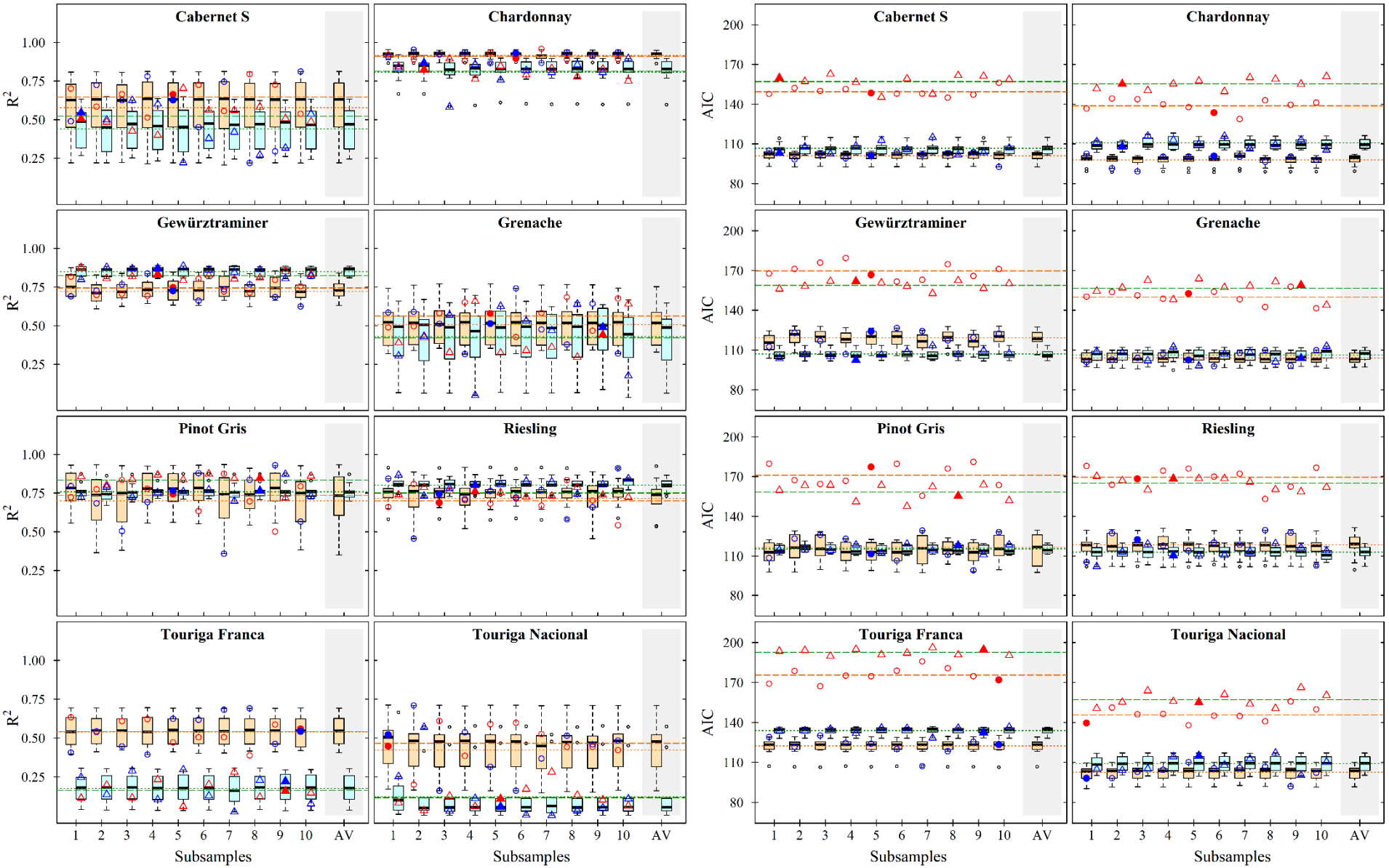
170
140
110
80
1 2 3 4 5 6 7 8 9 10 AV
Subsamples

Figure S5 - R^2 and AIC values of the UNIFORC model obtained for all fitted and average models, grapevine varieties and starting dates. The symbols (points and triangles) show the model results at two starting dates (in this example t_0 = 1 and 60 DOY), while the two colours represent fitting (red) and validation (blue) procedure, respectively. The filled symbols constitute the R^2 and AIC values of the models obtained by the selected HP parameter sets, while the dashed (fitting) and dotted (validation) lines depict the average R^2 and AIC values for both starting dates (in this example orange line = 1 DOY and green line = 60 DOY). The boxplots represent the R^2 and AIC values distribution for HP (orange and light blue: HP model application on all validation sub-samples for t_0 = 1 and t_0 = 60 DOY, respectively) and AV (boxplot in the shaded area, orange and light blue: AV application on all validation sub-samples for t_0 = 1 and t_0 = 60 DOY, respectively). The outliers represent all values out of the 1.5*InterQuartile Range (IQR) of the boxplot.


Cabernet S
Chardonnay
Gewürztraminer
Grenache
Pinot Gris
Riesling
Touriga Franca
Touriga Nacional
R2
AIC
1.00
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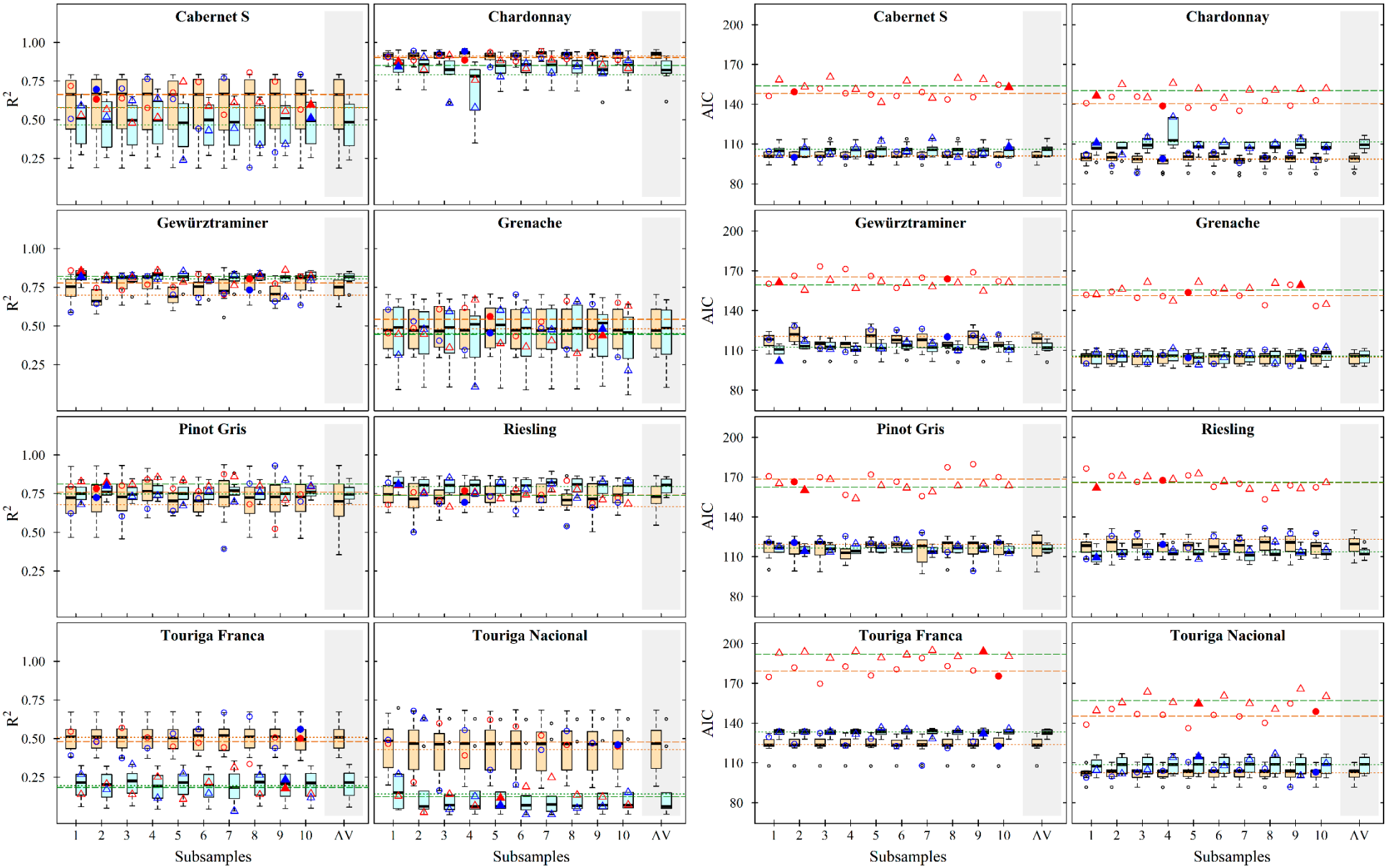
1 2 3 4 5 6 7 8 9 10 AV
Subsamples

Figure S6 - R^2 and AIC values of the GDD model obtained for all fitted and average models, grapevine varieties and starting dates. The symbols (points and triangles) show the model results at two starting dates (in this example t_0 = 1 and 60 DOY), while the two colours represent fitting (red) and validation (blue) procedure, respectively. The filled symbols constitute the R^2 and AIC values of the models obtained by the selected HP parameter sets, while the dashed (fitting) and dotted (validation) lines depict the average R^2 and AIC values for both starting dates (in this example orange line = 1 DOY and green line = 60 DOY). The boxplots represent the R^2 and AIC values distribution for HP (orange and light blue: HP model application on all validation sub-samples for t_0 = 1 and t_0 = 60 DOY, respectively) and AV (boxplot in the shaded area, orange and light blue: AV application on all validation sub-samples for t_0 = 1 and t_0 = 60 DOY, respectively). The outliers represent all values out of the 1.5*InterQuartile Range (IQR) of the boxplot.


Cabernet S
Chardonnay
Gewürztraminer
Grenache
Pinot Gris
Riesling
Touriga Franca
Touriga Nacional
R2
AIC
1.00
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1 2 3 4 5 6 7 8 9 10 ΛV
Subsamples

Figure S7 - R^2 and AIC values of the WANG model obtained for all fitted and average models, grapevine varieties and starting dates. The symbols (points and triangles) show the model results at two starting dates (in this example t_0 = 1 and 60 DOY), while the two colours represent fitting (red) and validation (blue) procedure, respectively. The filled symbols constitute the R^2 and AIC values of the models obtained by the selected HP parameter sets, while the dashed (fitting) and dotted (validation) lines depict the average R^2 and AIC values for both starting dates (in this example orange line = 1 DOY and green line = 60 DOY). The boxplots represent the R^2 and AIC values distribution for HP (orange and light blue: HP model application on all validation sub-samples for t_0 = 1 and t_0 = 60 DOY, respectively) and AV (boxplot in the shaded area, orange and light blue: AV application on all validation sub-samples for t_0 = 1 and t_0 = 60 DOY, respectively). The outliers represent all values out of the 1.5*InterQuartile Range (IQR) of the boxplot.

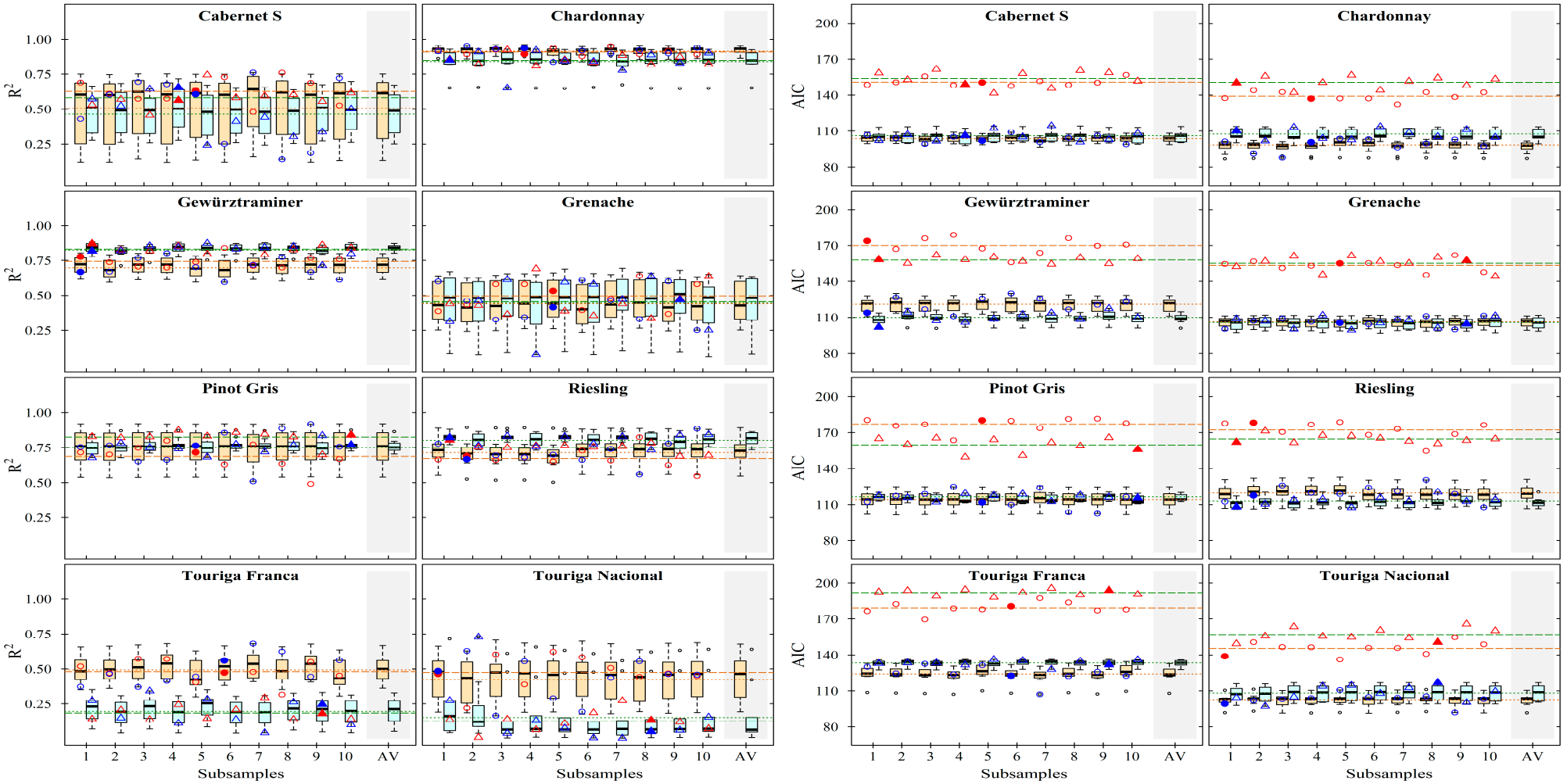
Cabernet S
Chardonnay
Gewürztraminer
Grenache
Pinot Gris
Riesling
Touriga Franca
Touriga Nacional
R2
AIC
Subsamples
1 2 3 4 5 6 7 8 9 10 AV

Figure S8 - Correlations between observed and simulated budbreak Days Of Year (DOY) of the UNIFORC and UNICHILL models. The results were obtained for all grapevine varieties and starting dates using the HP parameter set.

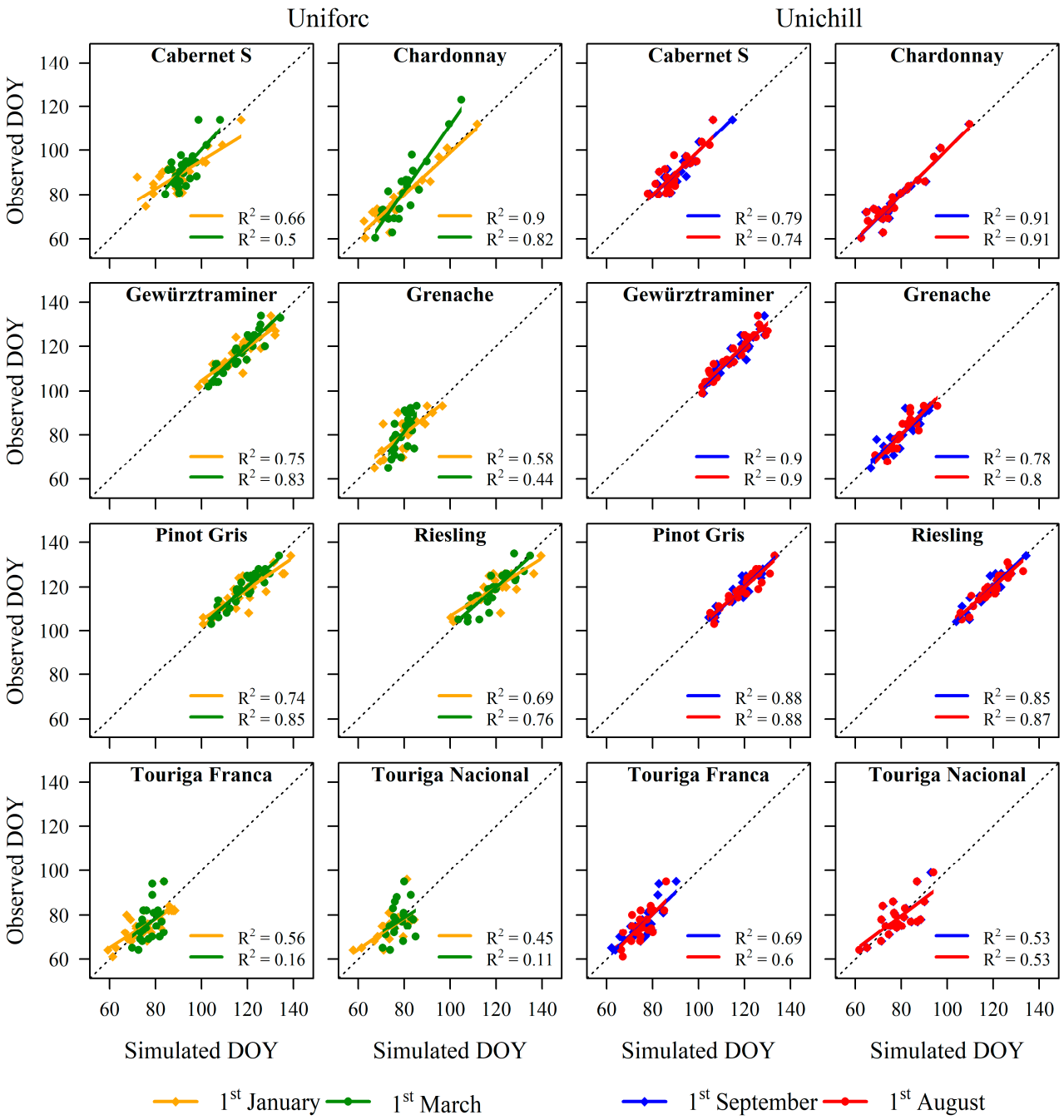

Figure S9 - Correlations between observed and simulated budbreak Days Of Year (DOY) of the WANG and BRIN Daily models. The results were obtained for all grapevine varieties and starting dates using the HP parameter set.

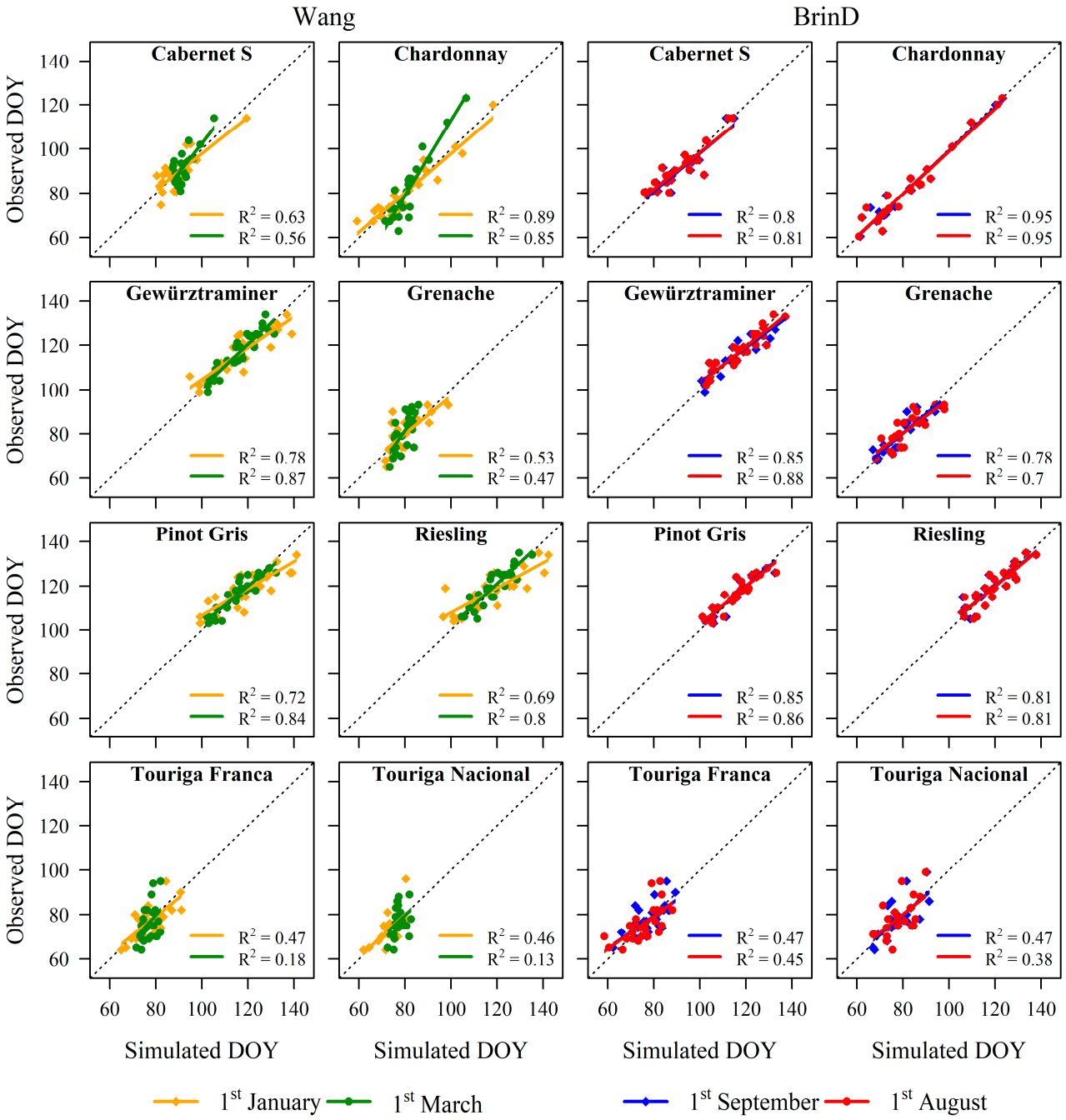

Figure S10 - Highest-Performance (HP) and average (AV) parameters' set applied on the independent datasets by considering all phenological models and starting dates. The example of Cabernet sauvignon variety.

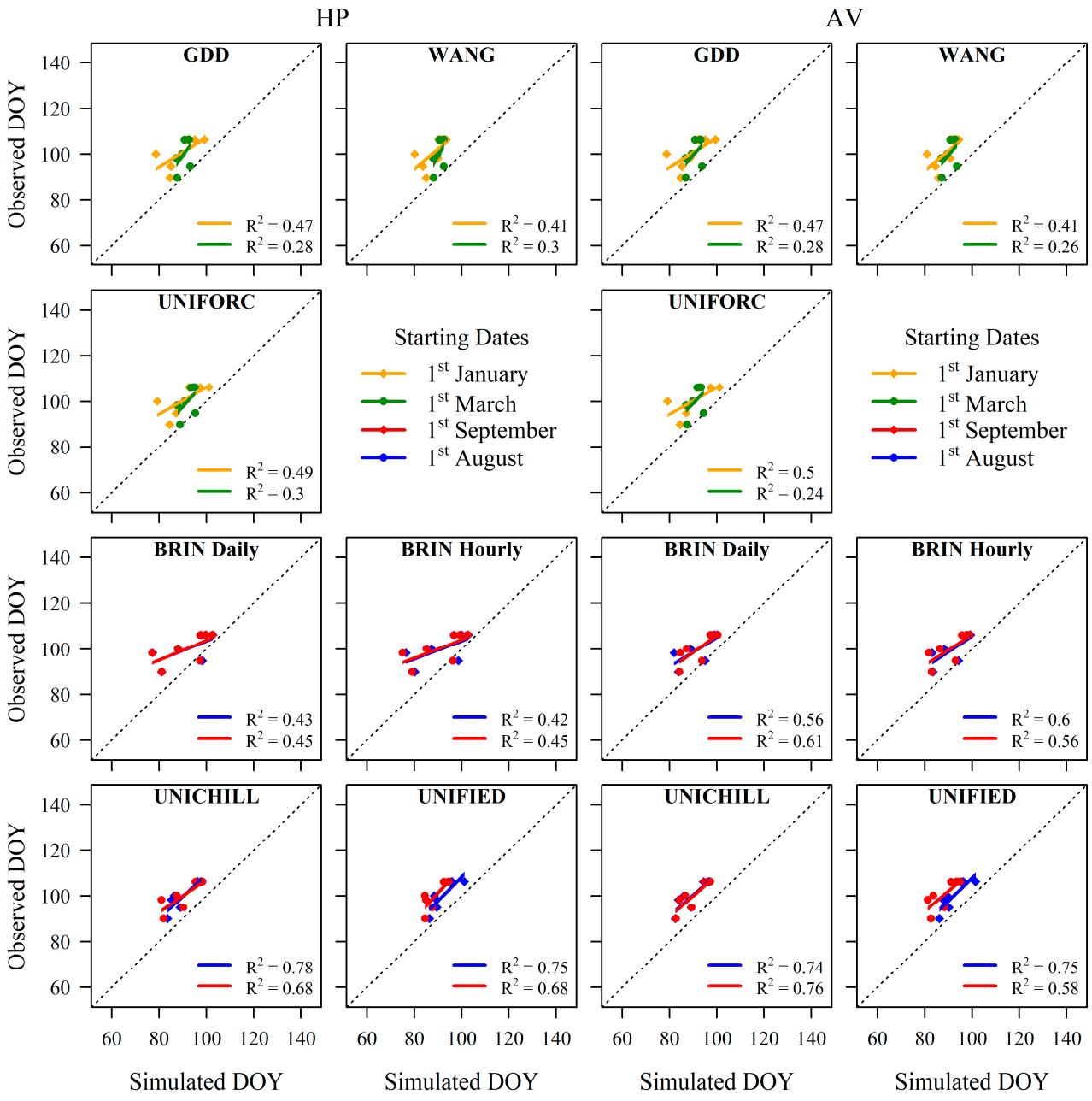

Figure S11 - Highest-Performance (HP) and average (AV) parameters' set applied on the independent datasets by considering all phenological models and starting dates. The example of Gewürztraminer variety.

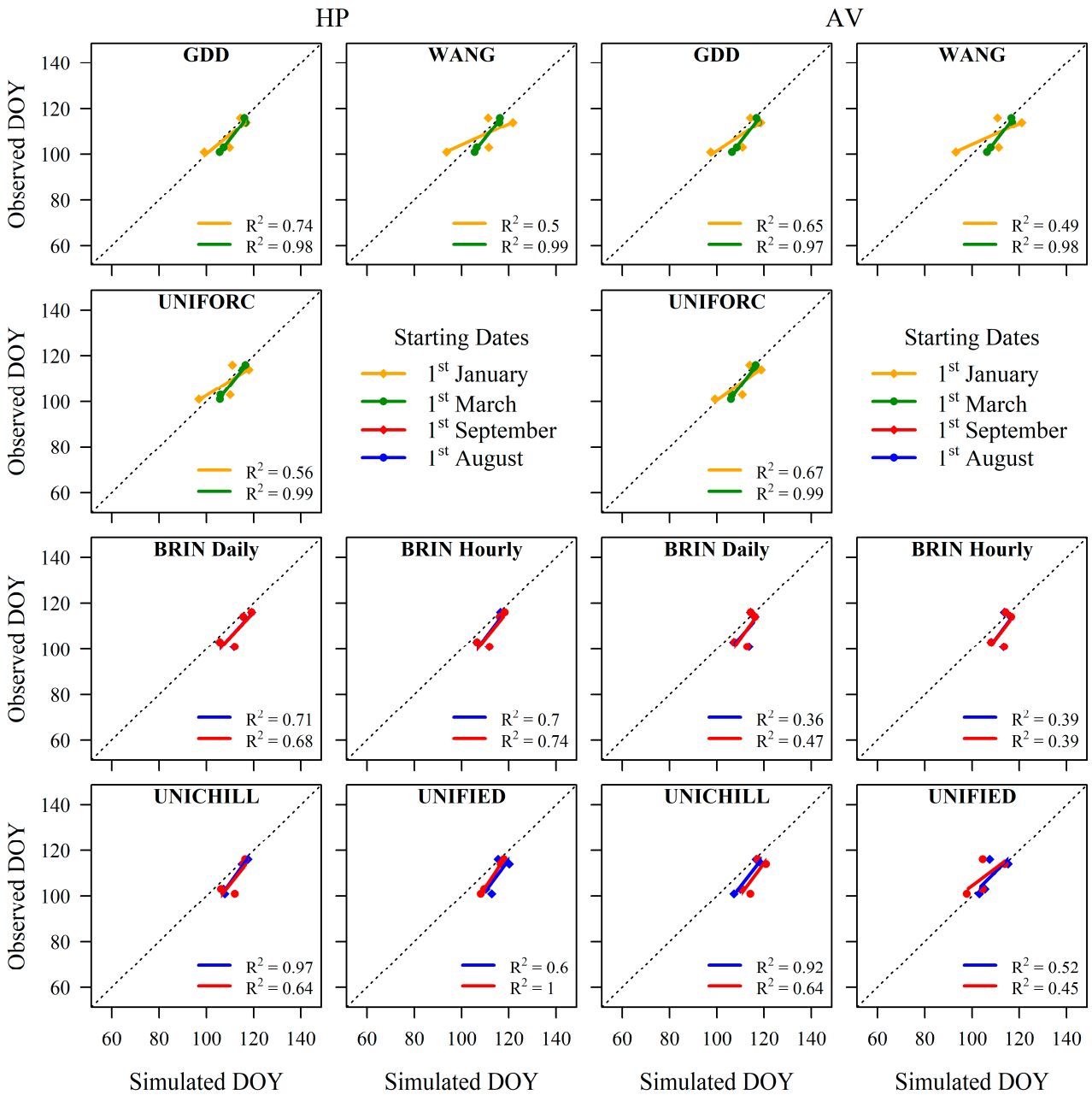

Figure S12 - Highest-Performance (HP) and average (AV) parameters' set applied on the independent datasets by considering all phenological models and starting dates. The example of Grenache variety.

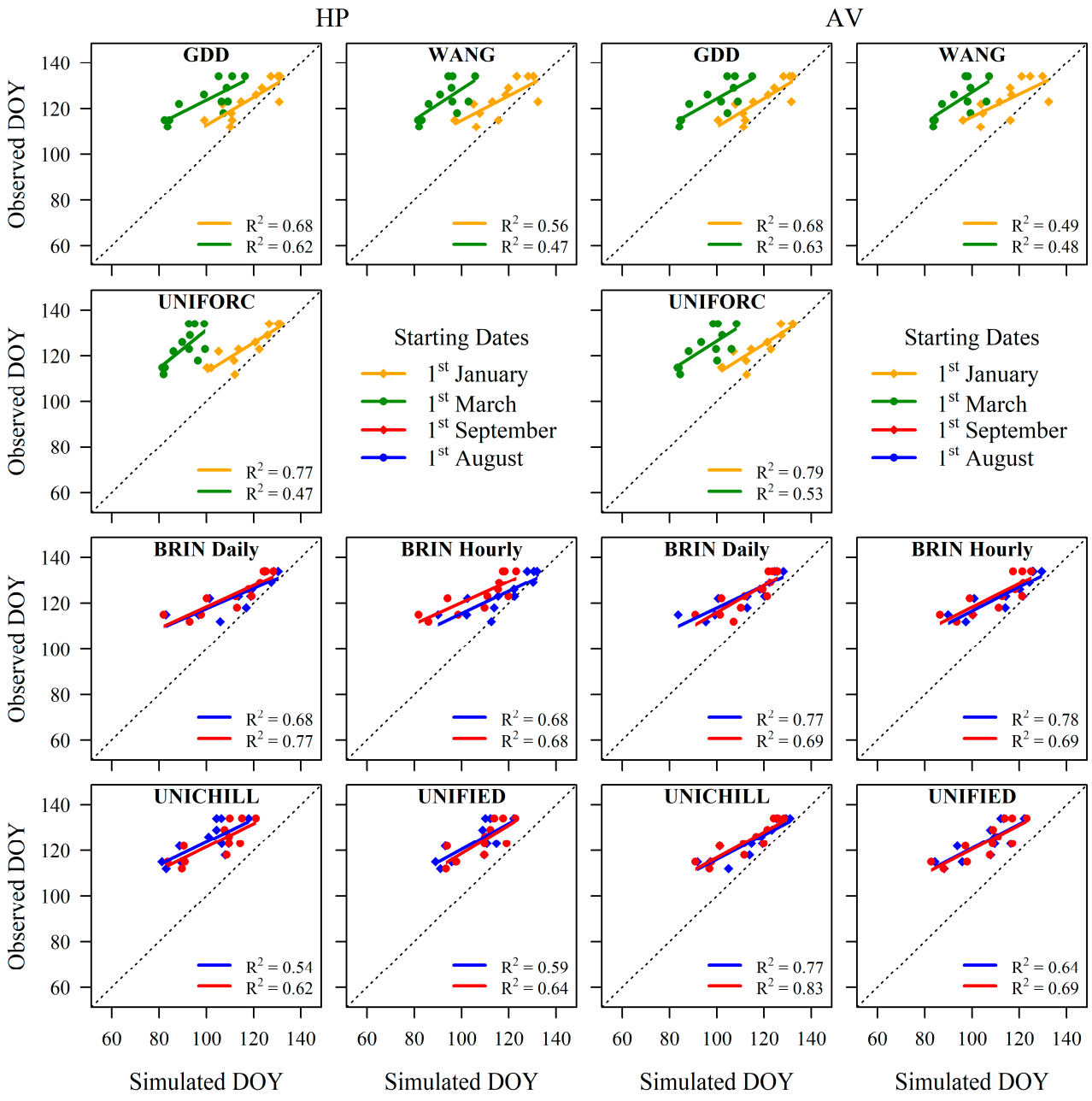

Figure S13 - Highest-Performance (HP) and average (AV) parameters' set applied on the independent datasets by considering all phenological models and starting dates. The example of Pinot Gris variety.

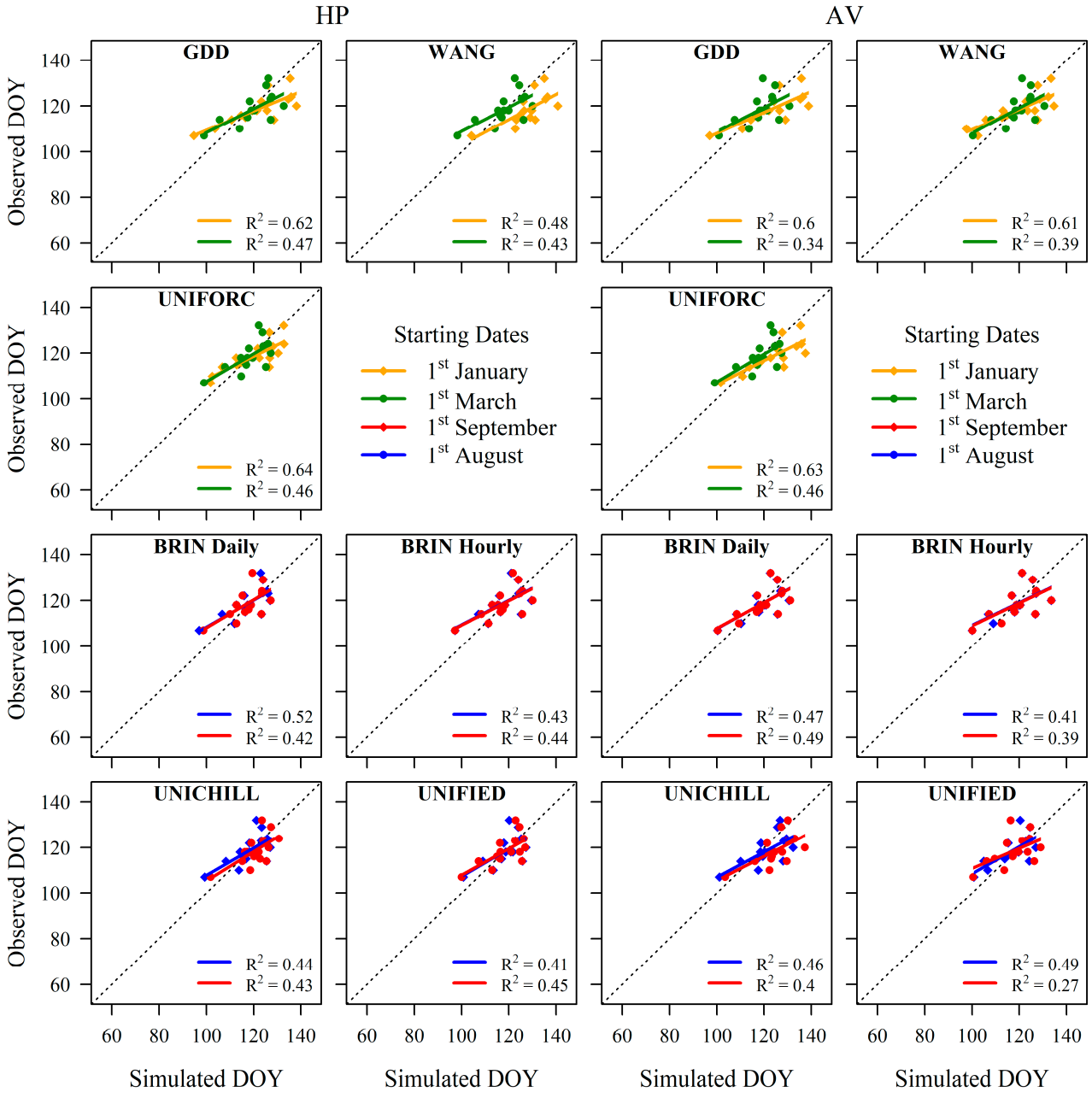

Figure S14 - Highest-Performance (HP) and average (AV) parameters' set applied on the independent datasets by considering all phenological models and starting dates. The example of Riesling variety.

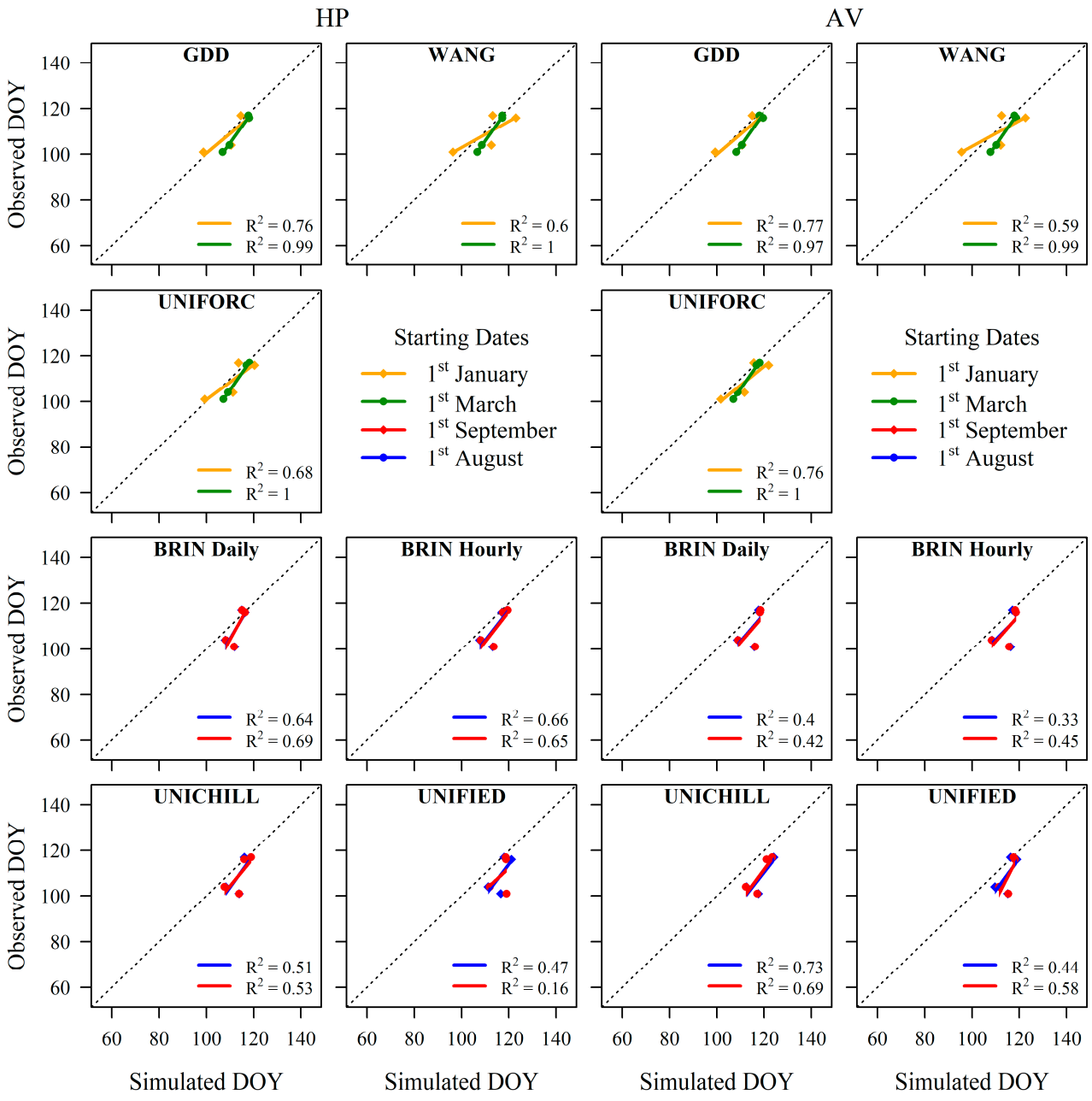

Figure S15 - Highest-Performance (HP) and average (AV) parameters' set applied on the independent datasets by considering all phenological models and starting dates. The example of Touriga Franca variety.

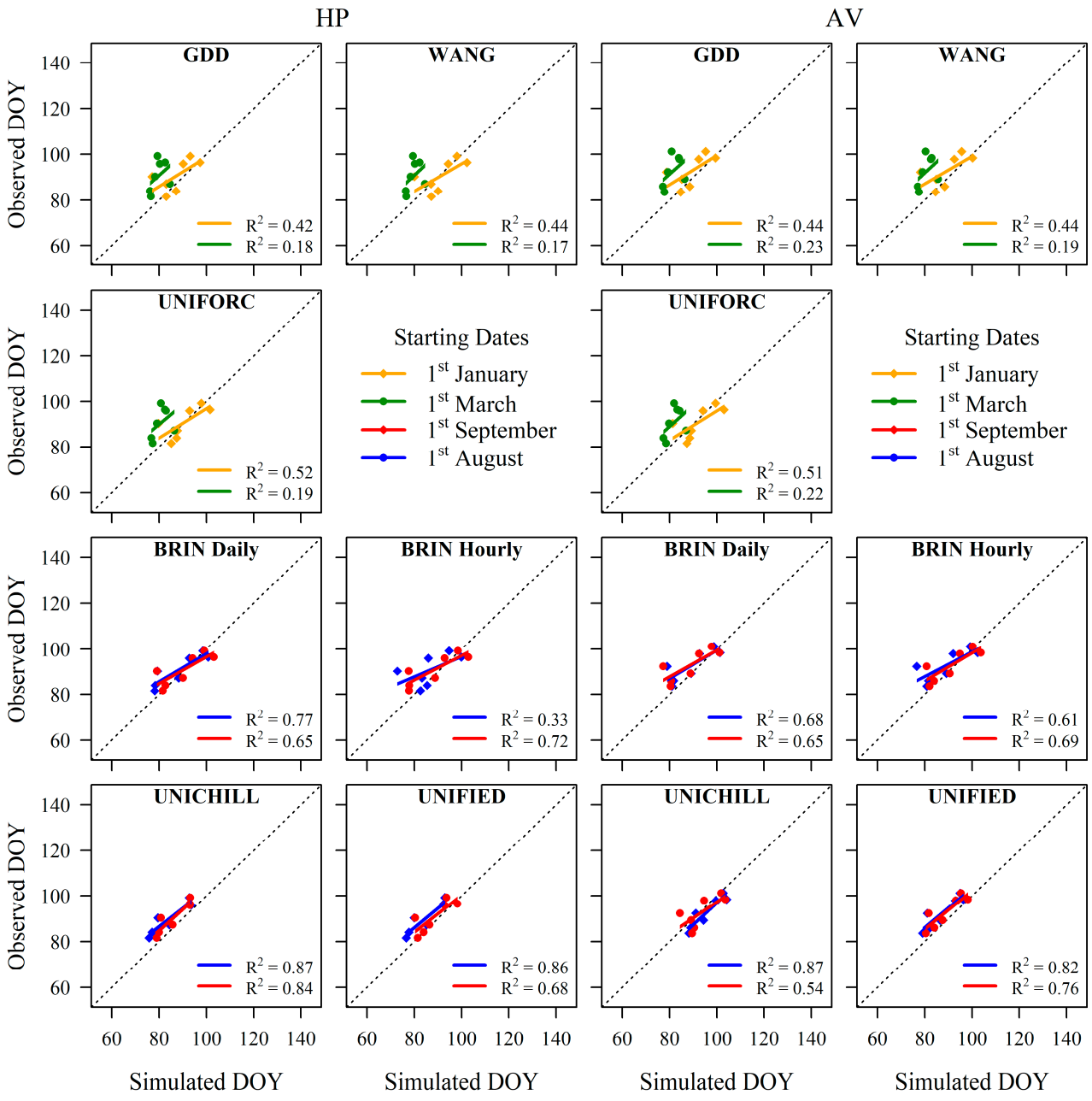

Figure S16 - Highest-Performance (HP) and average (AV) parameters' set applied on the independent datasets by considering all phenological models and starting dates. The example of Touriga Nacional variety.

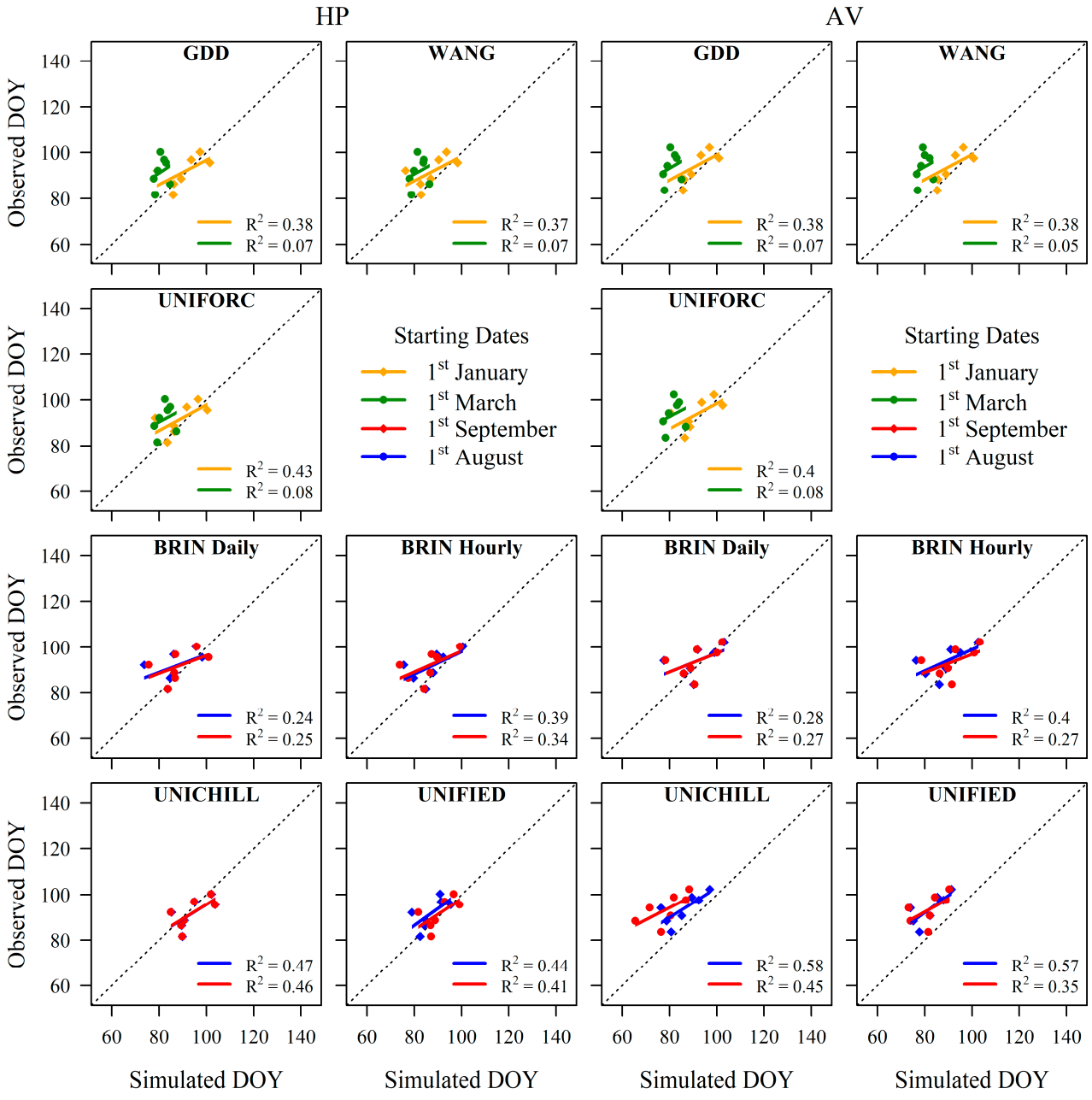

Figure S17 – Statistical results (R^2, AIC and RMSE) of the comparison between CF (black bars) and F (red bars) models in model fitting and application for all grapevine varieties using AV parameters' set. The differences between CF and F models in model fitting and applications were displayed using green and yellow bars, respectively. CS = Cabernet Sauvignon, CH = Chardonnay, GE = Gewürztraminer, GR = Grenache, PG = Pinot Gris, RS = Riesling, TF = Touriga Franca, TN = Touriga Nacional.