SUPPLEMENTARY DATA

Table S1. Number of RCMs of each GCM used in the study for the baseline (1976 – 2005) and the RCPs 2.6 and 4.5 (near-future, 2026 – 2055).

GCM	Acronym	Baseline	RCP 2.6	RCP 4.5	TOTAL
CNRM-CERFACS-CNRM-CM5	CNRM	2	-	2	4
ICHEC-EC-EARTH	ICHEC	6	5	5	16
MIROC-MIROC5	MIROC5	2	2	-	4
MOHC-HadGEM2-ES	MOHC	4	3	3	10
MPI-M-MPI-ESM-LR	MPILR	5	5	4	14
NCC-NorESM1-M	NorESM1	2	1	1	4
IPSL-IPSL-CM5A-LR	IPSLLR	1	1	-	2
NOAA-GFDL-GFDL-ESM2G	NOAA	1	1	-	2
IPSL-IPSL-CM5A-MR	IPSLMR	2	-	2	4
TOTAL		25	18	17	60

Table S2. Percentage (%) grid points in which budbreak date was not simulated by 20% or more of the cases by a phenological model for the baseline (1976 – 2005) and the near-future (2026 – 2055) summarized from Figure 2.

	Variety	FCF	F	CF	GDD	UNIFORC	WANG	BRIN	UNICHILL	UNIFIED
1976-2005	CH	6.9	3.7	6.9	3.5	2.6	3.7	4.5	2.8	6.2
	CS	13.6	5.2	13.6	5	4.9	2.9	4.5	0.9	13.2
	GE	10.5	5.6	8.9	5.6	3.5	4.1	4.5	7.1	6.8
	GR	7.6	3.3	7.6	3.2	3.0	2.2	4.2	6.0	2.0
	PG	13.2	5.9	11.0	5.9	4.4	4.2	4.0	7.9	6.2
	RI	35.0	5.8	33.6	5.8	4.0	4.3	5.1	32.8	11.4
	TF	10.0	5.8	10.0	4.9	5.2	5.8	6.3	9.6	3.9
	TN	13.7	5.8	13.7	5.8	4.9	5.4	7.7	6.3	13.4
2026-2055	CH	2.9	2.9	1.8	1.7	1.0	1.8	2.4	1.5	1.7
	CS	8.9	8.9	2.4	2.3	2.3	1.1	2.4	0.3	8.3
	GE	10.4	9.2	3.3	3.3	1.6	2.1	4.0	7.8	7.6
	GR	7.3	7.3	1.4	1.3	1.3	0.8	2.2	6.4	0.5
	PG	13.8	11.8	3.5	3.5	2.3	2.1	3.8	10.8	5.0
	RI	33.6	32.2	3.3	3.3	2.0	2.2	5.1	31.3	11.9
	TF	5.3	5.3	2.9	2.2	2.5	2.9	3.5	4.7	1.6
	TN	8.4	8.4	2.9	2.9	2.4	2.6	4.4	3.1	7.9

Table S3. Average and standard deviation (within brackets) in the percentage of the uncertainties for $\overline{PHE}$, $\overline{GCM}$, $\overline{RCM}$, $\overline{RCP}$ and their first order interactions (*var1:var2*) by grape variety and period (baseline = 1976-2005, near-future = 2026-2055) for both phenological model types separately (Forcing and Chilling-Forcing). $\overline{RES}$ are the average residuals of each grid-point ANOVA and $\overline{Ncases}$ are the average number of cases (30-year periods of the available RCMs) in which the budbreak is simulated. The abbreviations of the varieties are in Table 1.

		Var	$\overline{TSS}$	$\overline{PHE}$	$\overline{GCM}$	$\overline{RCM}$	$\overline{RCP}$	$\overline{PHE:GCM}$	$\overline{PHE:RCM}$	$\overline{PHE:RCP}$	$\overline{GCM:RCM}$	$\overline{GCM:RCP}$	$\overline{RCM:RCP}$	$\overline{RES}$
Forcing	1976-2005	CH	520.8 (314.8)	82.1 (23.3)	10.7 (15.6)	4.1 (5.8)	-	0.5 (0.6)	0.4 (0.7)	-	2.1 (2.9)	-	-	0.1 (0.3)
		CS	1679.7 (1758.3)	93.0 (10.1)	3.6 (6.3)	1.3 (1.8)	-	0.8 (1.0)	0.5 (0.9)	-	0.6 (1.1)	-	-	0.2 (0.6)
		GE	433.9 (713.4)	73.8 (20.5)	13.5 (10.4)	7.0 (8.6)	-	0.8 (0.8)	0.7 (0.9)	-	3.8 (4.7)	-	-	0.3 (0.7)
		GR	1063.2 (876.8)	90.0 (13.6)	5.4 (8.5)	2.1 (3.0)	-	0.8 (1.1)	0.6 (1.0)	-	0.9 (1.6)	-	-	0.2 (0.5)
		PG	530.8 (714.9)	78.6 (22.1)	10.4 (10.9)	5.9 (8.4)	-	0.9 (1.0)	0.8 (1.0)	-	3.1 (4.3)	-	-	0.4 (0.6)
		RI	366.1 (570.0)	75.9 (20.5)	12.1 (10.1)	6.6 (8.3)	-	0.8 (0.9)	0.7 (0.9)	-	3.5 (4.4)	-	-	0.3 (0.7)
		TF	667.8 (417.7)	91.8 (7.9)	4.7 (4.9)	1.8 (2.1)	-	0.4 (0.5)	0.3 (0.5)	-	1.0 (1.3)	-	-	0.1 (0.4)
		TN	670.2 (471.4)	88.8 (12.9)	6.2 (7.2)	2.7 (4.0)	-	0.4 (0.5)	0.3 (0.5)	-	1.3 (2.0)	-	-	0.1 (0.4)
	2026-2055	CH	1609.4 (840.2)	36.9 (22.7)	38.8 (17.4)	14.3 (7.2)	2.1 (2.6)	0.3 (0.3)	0.2 (0.2)	<0.1 (<0.1)	2.8 (1.9)	2.3 (3.3)	1.8 (1.9)	0.4 (0.4)
		CS	2994.2 (2239.5)	55.5 (27.4)	26.4 (17.5)	9.9 (7.8)	1.3 (1.7)	1.6 (1.4)	0.8 (0.8)	0.1 (0.1)	1.8 (1.6)	1.1 (1.4)	0.8 (0.9)	0.8 (0.6)
		GE	1484.2 (1162.8)	27.0 (25.7)	41.2 (16.6)	20.4 (11.7)	2.0 (2.2)	0.8 (0.7)	0.4 (0.3)	<0.1 (<0.1)	3.7 (2.6)	2.0 (2.1)	2.0 (1.8)	0.6 (0.4)
		GR	2265.0 (1311.0)	48.1 (27.8)	31.7 (18.8)	11.4 (8.0)	1.6 (2.1)	1.2 (1.0)	0.6 (0.6)	0.1 (0.1)	2.2 (1.7)	1.5 (2.0)	1.1 (1.2)	0.6 (0.6)
		PG	1609.4 (1183.7)	33.5 (25.4)	37.1 (16.9)	18.5 (10.4)	1.8 (2.0)	0.9 (0.9)	0.4 (0.4)	<0.1 (<0.1)	3.4 (2.4)	1.9 (2.1)	1.8 (1.5)	0.6 (0.4)
		RI	1456.9 (1051.1)	28.5 (25.0)	40.3 (16.7)	20 (11.1)	1.9 (2.0)	0.7 (0.7)	0.4 (0.3)	<0.1 (<0.1)	3.7 (2.5)	2.0 (2.2)	2.0 (1.7)	0.6 (0.4)
		TF	1753.1 (817.1)	44.8 (20.9)	33.9 (15.4)	13.1 (7.3)	1.7 (2.0)	0.6 (0.5)	0.3 (0.2)	<0.1 (<0.1)	2.3 (1.6)	1.7 (2.2)	1.2 (1.2)	0.4 (0.4)
		TN	1763.2 (880.5)	43.7 (23.8)	35.0 (17.8)	13.0 (7.2)	1.7 (2.0)	0.5 (0.5)	0.2 (0.2)	<0.1 (<0.1)	2.4 (1.6)	1.8 (2.5)	1.3 (1.4)	0.4 (0.4)
Chilling-Forcing	1976-2005	CH	927.1 (1277.8)	91.1 (5.9)	4.9 (3.7)	1.8 (1.9)	-	0.6 (0.7)	0.4 (0.4)	-	1.0 (0.9)	-	-	0.2 (0.3)
		CS	2085.4 (4142.0)	90.3 (14.0)	4.6 (6.7)	1.9 (4.1)	-	1.0 (1.3)	0.9 (1.1)	-	1.0 (1.8)	-	-	0.3 (0.4)
		GE	1461.8 (4860.0)	69.1 (27.8)	17.6 (17.7)	6.5 (8.0)	-	1.3 (2.1)	0.9 (1.3)	-	4.1 (4.7)	-	-	0.4 (1.0)
		GR	1848.5 (1358.9)	96.6 (4.9)	1.8 (2.7)	0.7 (1.2)	-	0.3 (0.6)	0.2 (0.3)	-	0.3 (0.5)	-	-	0.1 (0.2)
		PG	1098.6 (3742.8)	73.2 (23.0)	15.1 (14.0)	5.7 (6.4)	-	1.1 (1.3)	0.8 (0.9)	-	3.7 (4.8)	-	-	0.4 (0.8)
		RI	418.8 (667.9)	75.4 (23.3)	12.9 (13.6)	4.2 (4.5)	-	2.3 (3.7)	1.4 (1.9)	-	3.0 (2.9)	-	-	0.8 (1.9)
		TF	1183.4 (683.9)	96.2 (2.2)	2.0 (1.3)	0.8 (0.8)	-	0.3 (0.4)	0.2 (0.3)	-	0.4 (0.4)	-	-	0.1 (0.2)
		TN	1787.9 (1929.2)	97.1 (1.5)	1.3 (0.7)	0.5 (0.4)	-	0.4 (0.4)	0.3 (0.3)	-	0.3 (0.2)	-	-	0.1 (0.2)
	2026-2055	CH	2113.2 (2208.8)	43.6 (23.3)	31.8 (13.9)	15.3 (10.1)	1.5 (1.8)	0.7 (0.5)	0.5 (0.6)	<0.1 (<0.1)	2.9 (2.4)	1.5 (1.8)	1.6 (1.6)	0.5 (0.3)
		CS	2853.4 (3830.0)	48.9 (26.8)	27.5 (15.8)	13.2 (9.4)	1.3 (1.7)	1.8 (1.8)	1.0 (0.6)	0.1 (0.1)	2.7 (2.3)	1.6 (2.5)	1.1 (1.3)	0.9 (0.7)
		GE	2371.0 (5286.4)	32.7 (33.5)	36.5 (21.0)	19.1 (12)	1.8 (2.2)	1.3 (1.5)	0.7 (0.8)	0.1 (0.1)	3.6 (2.7)	1.4 (1.3)	2.1 (2.0)	0.7 (0.5)
		GR	3188.4 (2070.7)	71.0 (12.1)	15.9 (6.5)	7.5 (4.7)	0.8 (1.0)	0.8 (1.3)	0.4 (0.3)	<0.1 (0.1)	1.5 (1.3)	0.8 (1.4)	1.0 (1.1)	0.4 (0.6)
		PG	1605.2 (3036.2)	31.5 (30.7)	37.5 (19.6)	19.2 (11.4)	1.8 (2.0)	1.1 (1.3)	0.7 (0.9)	0.1 (0.1)	3.6 (2.7)	1.6 (1.5)	2.2 (1.8)	0.7 (0.5)
		RI	1137.4 (858.4)	33.6 (27.2)	35.3 (18.1)	18.5 (10.6)	1.6 (2.0)	1.7 (1.5)	0.9 (0.9)	0.1 (0.1)	3.4 (2.4)	1.8 (1.5)	2.1 (1.8)	1.0 (0.8)
		TF	2312.0 (1283.2)	60.5 (11.5)	22.5 (8.0)	10.6 (5.9)	1.0 (1.1)	0.7 (0.8)	0.3 (0.3)	<0.1 (0.1)	2.0 (1.4)	1.1 (1.4)	1.0 (1.1)	0.4 (0.3)
		TN	3517.6 (3660.9)	66.3 (12.9)	19.8 (8.4)	8.6 (5.5)	1.0 (0.7)	0.7 (0.4)	0.4 (0.3)	0.1 (<0.1)	1.6 (1.2)	0.7 (0.8)	0.5 (0.7)	0.3 (0.2)

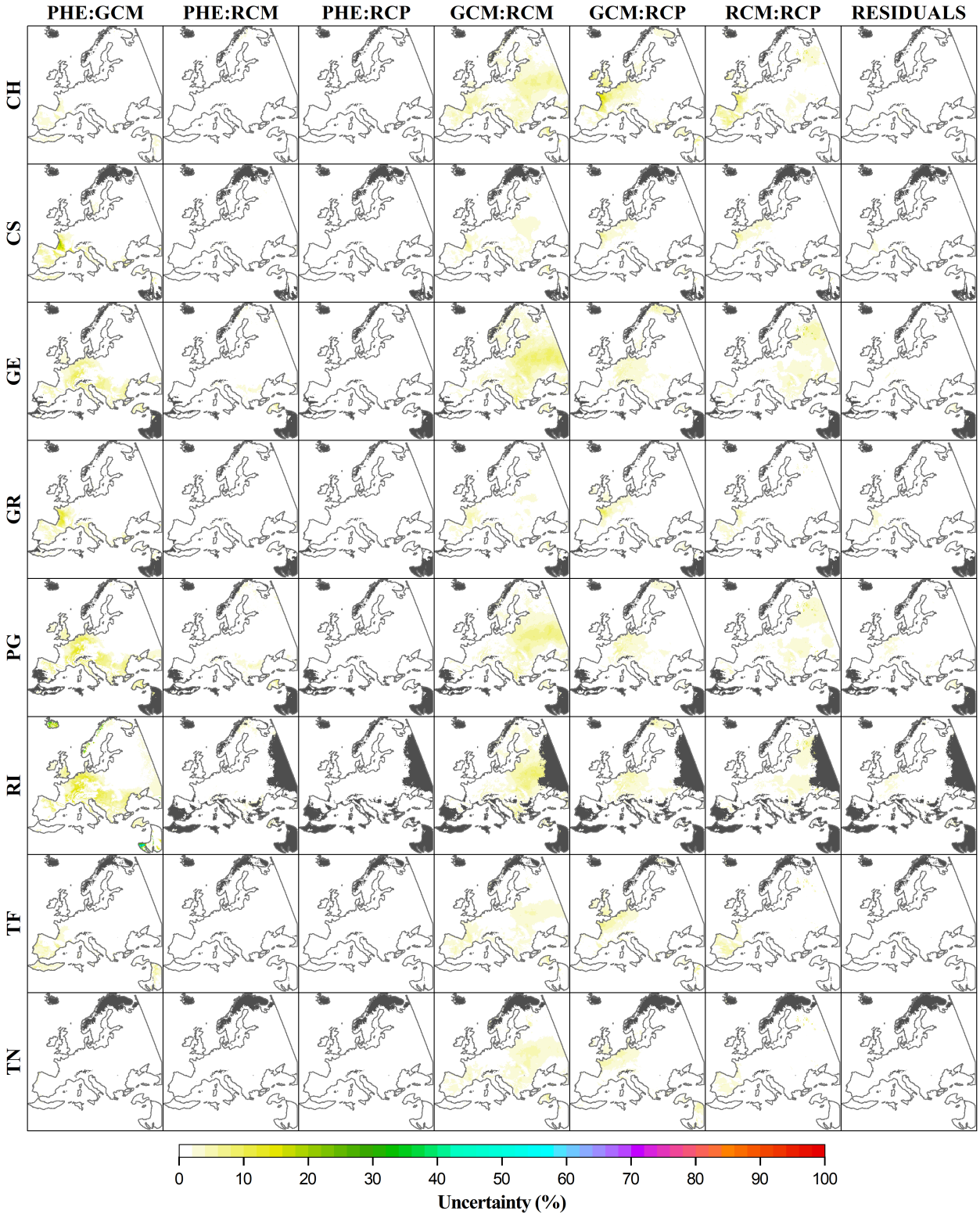


Figure S1. Spatial distribution of the uncertainty (%) from the first order interactions (*var1:var2*) between PHE, GCM, RCM and RCP and the residuals of the ANOVA across Europe for the future period (2026-2055). Dark regions evidence the grid points in which budbreak date was not simulated by 20% or more of the cases by a phenological model.

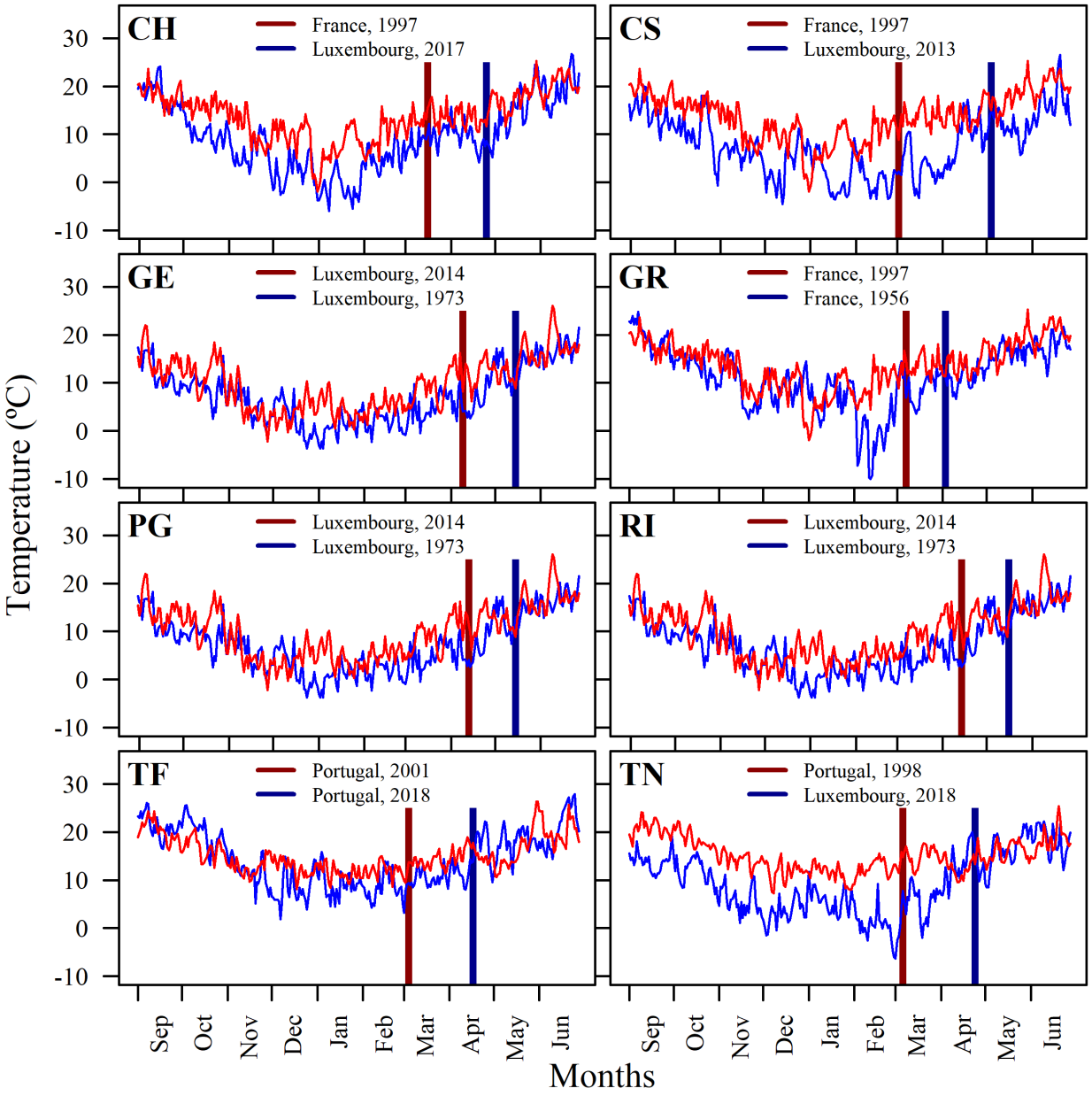


Figure S2. Comparison between different temperature trends (Red line – Tmean trend warmer year; Blue line – Tmean trend cooler year) and budbreak occurrence (Red bar – earlier observed budbreak; Blue bar – later observed budbreak) observed from 1 September to the latest observed budbreak occurrence for all varieties and years. For the information regarding the observed datasets, please refer to Table 1, Leolini *et al*. (2020).