

Continental atmospheric circulation over Europe during the Little Ice Age inferred from harvest dates

Supplementary Information

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Supplementary Tables

Table 1. Main characteristics of the 9 composites series of grapevine harvest dates used in this study. \$ mean temperature over March 15th to August 31st. * Important varieties identified in the region which are not used in our study because of insufficient data to calibrate the model. **Mean GHD is in day after August 31st.

Series name	Number of Series	Period covered (number of years)	Missing years	Reference Serie	Mean Temperature \$ 1969-1980	Weather station	mean GHD**	GHD standard deviation	Varieties cultivated
Rhone valley (South)	51	1433-2006 (574)	123	Pernes les Fontaines; Couvent des Pernes	17.80	Carpentras 44°5'N, 05°03'E	23.26	9.62	Grenache, Muscat à petits grains, Piquepoul blanc, Piquepoul noir, Aspiran*, Brun Fourca, Calitor*, Clairette, Colombaud, Œillade, Terret noir*, Terret blanc*, Terret gris
Alsace (North)	16	1700-2005 (306)	44	Ribeauvillé; Riquewihr	14.61	Colmar 48°03'N, 07°19'E	38.25	9.56	Chasselas, Muscat à petits grains, Pinot gris, Pinot noir, Riesling, Pinot blanc, Elbling, Knipplé, Savagnin rose
Ile de France (North)	16	1478-1977 (500)	81	Argenteuil	15.42	Montsouris 48°49'N, 02°20'E	27.50	10.39	Chasselas, Gamay, Gouais, Pinot gris, Meunier, Pinot noir, Savagnin, Pinot blanc, Meslier
Loire Valley – Saumur (West)	6	1801-2006 (206)	3	Chinon	15.42	Saumur 47°15'N, 00°04'W	40.17	9.52	Cabernet franc, Chenin*, Gouais, Cot, Pinot gris, Meunier, Pinot noir, Orbois
Bordeaux (West)	14	1449-2006 (558)	231	Pichon-Longueville	16.00	Mérignac 44°49'N, 00°41'W	25.05	9.84	Cabernet franc, Cot, Petit Verdot*, Carmenère*, Fer, Gros Cabernet, Mancin*, Pardotte
Burgundy (East)	20	1354-2006 (652)	39	Dijon	15.18	Ouge 47°16'N, 05°05'E	26.57	9.73	Gamay, Gouais, Pinot noir, Aligoté, Pinot blanc, Tressot
Jura (East)	16	1449-1976 (528)	86	Salins	14.96	Arbois 46°54'N, 05°44'E	40.53	10.57	Gamay, Gouais, Pinot noir, Poulsard, Savagnin, Trousseau, Enfariné
Leman Lake (East)	15	1480-2007 (528)	38	Lausanne	14.29	Genève 46°15'N, 06°08'E	38.85	11.42	Chasselas, Humagne blanche, Arvine, Amigne

Table 2. Model statistics with their formula and parameter estimates parameterized for the different grapevine varieties identified. ** Values of 10 and 90% confidence intervals respectively for T_{opt} and F^* parameters of the phenological process based model. ***Not enough data to calculate confidence intervals. n: number of observations and number of corresponding sites in parentheses. VM: Veraison model. VHM: Veraison-Harvest model. HM: harvest model. EF: efficiency. RMSE: root mean square error. RV: Rhône valley. Al: Alsace. Bo: Bordeaux. Bu: Burgundy. IdF: Ile de France. Ju : Jura. LV: Loire valley. Sw: Switzerland. Parameter t_0 was fixed to March 15th for all varieties.

Variety	Region	n	Period	VM EF	VM RMSE	VHM RMSE	HM max RMSE	Parameter estimates with confidence intervals			
								T_{opt}		F^*	
Aligoté	Bu	13(2)	1976-2000	0.85	4.3	5.9	7.3	26.5	(21.3 – 31.0)**	96.5	(49.5 – 128.8)**
Amigne	Sw	9(1)	1991-1999	0.65	3.32	8.0	8.7	28.25	(22.1 - 30.3)**	85.14	(61.3 - 136)**
Arvine	Sw	9(1)	1991-1999	0.59	2.88	8.0	8.5	26.72	(19.4-28.9)**	103.62	(79.5-151.7)**
Aspiran	RV	4(1)	1976-1998	0.88	1.68	6.3	6.5	24.86	(16.37-29.9)**	116.34	(70.4-144)**
Brun fourca	RV	4(1)	1976-1998	0.68	2.65	6.3	6.8	24.32	(7.5-32.2)**	117.12	(40.0-146.7)**
Cabernet franc	LV	115(20)	1976-2007	0.66	6.6	7.3	9.9	26.88	(25.4-28.1)**	100.39	(88.5-112.2)**
	Bo						9.3				
Calitor	RV	3(1)	1976-1978	-0.02	4.16	6.3	7.6	18.28	***	145.3	***
Carmenère	Bo	4 (1)	1976-1989	0.93	1.21	6.5	6.6	24.51	(18.2-28.5)**	114.35	(80.8-112.2)**
Chasselas	Al	72(4)	1976-2005	0.91	4.9	7.3	8.8	29.8	(28.5-30.8)**	60.15	(49.5-73)**
	IdF					4.5	6.7				
	Sw					8.0	9.4				
Chenin	LV	6(1)	1977-1982	-0.2	5.6	7.3	9.2	17.07	(1-29.3)**	142.53	(73.7-152.6)**
Clairette	RV	13(1)	1976-1996	0.64	4.88	6.3	8.0	29.12	(22.6-30.7)**	82.06	(62.7-130.8)**
Colombaud	RV	4(1)	1976-1998	0.68	3.98	6.3	7.5	26.61	(2.9-31.9)**	106.86	49.68-157.0)**
Cot	LV	13(2)	1976-1995	0.68	5.4	7.3	9.1	27.19	(20.28-30.69)**	96.03	(61.4-134.6)**
	Bo					6.5	8.5				
Elbling	Al	8(1)	1976-1997	0.79	3.92	7.3	8.3	28.34	(20.0-32.8)**	77.03	(30.8-124.97)**
Enfariné	Ju	4(1)	1990-1998	0.74	1.53	5.9	6.1	22.88	(3.2-33.0)**	121.9	(34.12-137.34)**
Fer	Bo	6(1)	1976-1981	0.28	5.17	6.5	8.3	27.52	(1.5-33.9)**	94.85	(20.9-150.4)**
Gamay	IdF	76(8)	1977-2007	0.69	5.2	4.5	6.9	27.2	(25.4 - 28.8)**	92	(77.3 – 106.1)**
	Bu-Ju					5.9	7.9				
	Sw					8.0	9.6				

Gouais	LV					7.3	8.4					
	Bu-Ju	7(1)	1976-1998	0.79	4.1	5.9	7.2	28.5	(18.6 – 28.5)**	77.8	(77.6 – 133.8)**	
	IdF					4.5	6.1					
Grenache	RV	134(37)	1977-2007	0.87	6.03	6.3	8.7	27.33	(26.6-27.9)**	99.76	(93.8-105.9)**	
Gros Cabernet	Bo	3(1)	1976-1979	0.99	0.37	6.5	6.5	28.13	***	88.03	***	
Humagne blanche	Sw	9(1)	1991-1999	0.68	2.97	8.0	8.5	27.74	(22.25-28.18)**	90.46	(86.7-134.9)**	
Knippelé	Al	3(1)	1977-1979	0.88	0.87	7.3	7.4	24.34	***	107.64	***	
Mancin	Bo	4(1)	1976-1989	0.85	1.94	6.5	6.8	24.99	(15.2-30.4)**	119.97	(67.7-149.9)**	
Meslier	IdF	6(1)	1976-1983	0.7	2.91	4.5	5.4	26.76	(17.1-31.3)**	95.05	48.7-134.7)**	
Meunier	LV	11(1)	1976-1996	0.62	3.88	7.3	8.3	27.21	(20.2-31.1)**	85.44	(46.7-122.5)**	
	IdF					4.5	5.9					
Muscat à petit grains	Al	15(2)	1976-1999	0.94	3.4	7.3	8.1	28.9	(26.0-30.8)**	74.71	(52.8-102.8)**	
	RV					6.3	7.2					
Œillade	RV	4(1)	1976-1998	0.95	1.18	6.3	6.4	25.65	20.3-29.0)**	108.4	(76.6-135.0)**	
Orbois	LV	11(1)	1976-2000	0.65	3.42	7.3	8.1	25.14	(18.9-29.4)**	105.1	(69.7-129.4)**	
Pardotte	Bo	4(1)	1976-1998	0.98	0.91	6.5	6.6	27.32	(24.3-29.6)**	95.47	(71.3-117.7)**	
Petit Verdot	Bo	29(4)	1976-2007	0.36	6.42	6.5	9.1	25.86	(20.9-29.4)**	114.44	(83.4-137.0)**	
Pinot blanc	Al	12(2)	1991 - 1999	0.91	4.1	7.3	8.4	27.6	(23.7 – 30.6)**	87	(54.9 – 117.8)**	
	Bu					5.9	7.2					
	IdF					4.5	6.1					
Pinot gris	Al-LV	15(2)	1976-1999	0.91	4.2	7.3	8.4	28.14	(24.3-30.9)**	80.7	(51.0-112.4)**	
	IdF					4.5	6.2					
Pinot noir	Al-LV	83(7)	1976-2007	0.76	7.6	7.3	10.5	27.4	(25.7 – 28.9)**	89.2	(74.0 – 104.2)**	
	Bu-Ju					5.9	9.6					
	IdF					4.5	8.8					
Piquepoul blanc	RV	6(2)	1976-2004	0.73	3.88	6.3	7.4	26.03	(17.8-31.09)**	109.26	(57.9-141.6)**	
Piquepoul noir	RV	7(1)	1976-1991	0.65	3.92	6.3	7.4	25.51	(16.0-30.8)**	112.81	(61.8-143.1)**	
Poulsard	Ju	7(1)	1976-1995	0.88	2.27	5.9	6.4	23.3	(16.9-28.2)**	113.07	(78.8-128.9)**	
Riesling	Al	55(6)	1962-2006	0.82	6.37	7.3	9.7	28.06	(26.3-29.6)**	85.66	(67.7-102.8)**	
Savagnin	IdF	15(2)	1976-1999	0.88	5.33	4.5	7.0	29.1	(25.6-31.5)**	72.7	(44.3-106.1)**	

	Ju					5.9	8.0				
Savagnin rose	Al	6(1)	1976-1996	0.78	2.97	7.3	7.9	26.68	(17.5-31.4)**	92.21	(46.8-130.0)**
Terret blanc	RV	7(1)	1988-1995	0.45	4.33	6.3	7.6	24.11	(1.8-32.1)**	124.36	(48.5-145.5)**
Terret gris	RV	10(1)	1976-1996	0.42	4.3	6.3	7.6	22.37	(13.6-28.4)**	133.2	(91.8-146.3)**
Terret noir	RV	4(1)	1976-1996	0.63	2.52	6.3	6.8	24.37	(6.9-32.2)**	121.99	(42.5-152.0)**
Tressot	Bu	10(1)	1976-2000	0.64	4.2	5.9	7.3	28.1	(20.4 – 30.7) **	85.6	(58.4 – 131.6)**
Trousseau	Ju	10(1)	1976-1996	0.82	3.19	5.9	6.7	25.85	(20.4-30.1)**	101.04	(62.1-126.9)**

	Climate dataset used in STICS crop model			Veraison – Harvest delay (<i>N</i>)	
	Region	Meteorological data	Period	Mean	Variance
South	Rhone valley	Avignon	1970-1989	38.5	39.7
North	Alsace	Colmar	1972-1989	33.3	53.3
	Ile de France	Paris	1960-1989	37.7	20.3
West	Loire Valley - Saumur	Angers	1979-1989	37.0	53.3
	Bordeaux	Bordeaux	1971-1989	38.1	42.3
Eastern	Burgundy	Dijon	1970-1989	33.7	35.2
	Jura*				
	Leman Lake (Switzerland)	Thonon les Bains	1971-1989	32.7	64.0

Table 3. Climate daily data used to calculate the Veraison–Harvest delay (*N* parameter) and its uncertainty with the STICS crop model. In all the cases we used at least 11 climatic years. * Jura parameters were assimilated to be the same as those of Burgundy.