

The plant phenological online database (PPODB): an online database for long-term phenological data

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Abstract We present an online database that provides unrestricted and free access to over 16 million plant phenological observations from over 8,000 stations in Central Europe between the years 1880 and 2009. Unique features are (1) a flexible and unrestricted access to a full-fledged database, allowing for a wide range of individual queries and data retrieval, (2) historical data for Germany before 1951 ranging back to 1880, and (3) more than 480 curated long-term time series covering more than 100 years for individual phenological phases and plants combined over Natural Regions in Germany. Time series for single stations or Natural Regions can be accessed through a user-friendly graphical geo-referenced interface. The joint databases made available with the plant phenological database *PPODB* render accessible an important data source for further analyses of long-term changes in phenology. The database can be accessed via www.ppodb.de.

Keywords Phenology database · Long-term data · Phenology data · Combined time series · Outliers · Plant phenology · Online access

Introduction

Plant phenological data, even though being low-technology subjective observations often made by volunteers, are a prerequisite

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of studies within several modern research fields, like, e.g., climate change (Badeck et al. 2004; Menzel and Fabian 1999; Wolkovich et al. 2012; Penuelas et al. 2009; Fridley 2012; Chuine et al. 2004; Menzel et al. 2006; Rosenzweig et al. 2007) and crop yields (Tao et al. 2006), and are of interest to the agro- and pharma-industries. As flexible and free access to phenological data is limited, we built an online database, which provides a flexible, free and unrestricted access to plant phenological observations. We compiled data from various sources and made it accessible in a consistent format. In addition, we digitized historical data, thereby, for the first time, providing phenological observations for 130 years (1880–2009) for a large geographical region, i.e. Germany, in a consistent format. The data can either be retrieved as time series with respect to a plant, phase and station by a simple geo-referenced interface, or by a full-fledged SQL database access allowing for a wide range of individual queries (examples given below). Moreover, we provide combined time series for Natural Regions, which are corrected for outliers.

Data and methods

In the following, we refer to ‘observation’ as the reported day of the year in which a certain phenological phase, e.g. blossoming, of a certain plant was observed at a certain location, i.e. station. The data in *PPODB* is compiled from three distinct databases (see Table 1 for summary statistics):

- Phenological observations collected by the Deutscher Wetterdienst (German meteorological service, DWD) from 1951 to 2009 (database DWD in Table 1).
- The historical phenological database provided by the DWD, which is a collection of phenological observations from Central Europe, mainly Germany, covering

Table 1 PPODB overview. Data are given as numbers of stations, phases, observations and observation periods in the different combined databases including plant varieties

Database	Plant type	Number of species	Number of phases	Number of stations	Number of observations	Observation period
DWD Lat: 47.4'–55', Lon: 6'–15'	Wild	37	75	6,514	5,897,274	1951–2009
	Agro	25	140	6,410	5,981,960	1951–2009
	Fruit	24	67	6,433	3,534,316	1951–2009
	Vine	4	27	1,176	100,609	1951–2009
	All	90	309	6,544	15,514,159	1951–2009
HIS Lat: 47.4'–55.1', Lon: 6.1'–22.5'	Wild	26	48	1,195	128,387	1921–1955
	Agro	40	157	1,262	50,630	1921–1955
	Fruit	20	64	1,191	45,924	1921–1955
	All	86	269	1,664	224,941	1921–1955
HPDB Lat: 18.8'–63.1', Lon: –76.6'–112.2'	Wild	28	58	1,099	109,782	1880–1941
	Agro	11	24	944	16,955	1880–1941
	Fruit	18	42	1,078	52,943	1880–1941
	NA ^a	290	1,398	1,161	122,015	1880–1941
	All	293	1,565	1,184	284,235	1880–1941
Combined data ^b Lat: 38.71'–63.1', Lon: –76.6'–112.2'	Wild	37	75	7,952	6,142,068	1880–2009
	Agro	47	249	7,807	6,064,664	1880–2009
	Fruit	31	99	7,859	3,623,751	1880–2009
	Vine	4	27	1,182	101,383	1951–2009
	NA ^a	277	1,344	1,073	116,185	1880–1944
	All	352	1,961	8,333	16,065,517	1880–2009

For a short description of the individuals databases (DWD, HIS, HPDB) and their sources refer to the Data and Methods section

^a Unspecified plant types refer to plant–phase combination that are not in the actual DWD database

^b The Combined Data refers to the database where stations and corresponding observations from all three databases have been combined and merged

the years 1880 until 1941 compiled from various sources (database HPDB in Table 1).

- To fill the gap between the two aforementioned databases, we digitized phenological data that were available only in printed form. These data were collected by the volunteer network of the Deutscher Reichswetterdienst, and were published after World War II. These observations cover the years 1922 until 1944. Additionally, we digitized phenological data that were published between 1951 and 1961 in the meteorological yearbooks of the DWD (DWD 1951, 1953, 1960, 1961, 1991). Taken together, these historical data cover the years 1921–1955 and is made publicly available here for the first time (database HIS in Table 1).

In Table 1 we also provide the geographical area covered in each of the databases, respectively. We provide a table of the countries, number of observations and observational time range per country in Supplementary Table S1. Please refer to the description of the online database at www.ppodb.de for more details and a full description of the database.

Results

There are three ways to access the database, i.e. time series access for single station or Natural Regions, or full-fledged SQL-access. We shortly illustrate these three main features.

When accessing the database via www.ppodb.de the user first encounters a page where two perspectives can be chosen, i.e. single stations or Natural Regions, for a certain group of plants (Fig. 1).

For clarity, we grouped the different plant types into agricultural plants, fruits, wild growing plants and vines.

Single stations

In the single station perspective plants, corresponding phases, and stations can be selected via drop-down menus (Fig. 2). Stations can additionally be selected by clicking on respective markers in the map. Initially,

Welcome to PPODB,

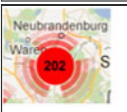
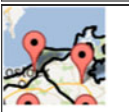



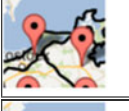
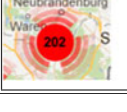
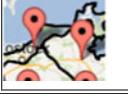
this Plant-Phenological Online Database offers access to plant-phenological observations in Central Europe mainly Germany, from about 9000 stations, covering 130 years (1880-2009), comprising over 16 millions observations.

The PPODB offers a unique data source, where, for the first time, plant-phenological observations from 129 years are brought together in one consistent database. Moreover, sophisticated outlier detection methods and quality checks are applied.

There are two ways to access the data:

- 1) In the [SQL-interface](#) we provide a full-fledged access to the complete database, allowing for highly flexible data retrieval via SQL-queries.
- 2) Below, we provide a visualization and access to phenological time series via a geo-referenced interface, using google-maps. Here you can visualize and retrieve phenological time series for a single station or a Natural Region, depending on the chosen perspective.

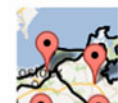
In order to access phenological time series, please select a combination of **plant type** and **perspective** from the table below by clicking on the corresponding image:

plant type	perspective	
	single stations	Natural Regions
agriculture		
fruits		
wild growing plants		
vines		

At the moment available perspectives are:



single stations: Here you can select single stations to analyze data.



natural regions: Here you can select Natural Regions to analyze your data.

PPODB is optimized for Firefox and Google Chrome. You might have problems with Internet Explorer.

Fig. 1 PPODB start interface (screenshot from browser)

a map of Central Europe is displayed where most of the stations are grouped into clusters indicated by coloured circles for a better overview. The numbers on the coloured circles indicate the number of stations which are represented by this cluster. Clicking on cluster symbols zooms into the map, where the location of single stations becomes visible. Single stations are marked by red balloons, which contain some general information about the station, like station name, longitude, latitude, altitude, number and range of years in which observations were made (Fig. 2).

Once plant, phase and station are selected, the corresponding time series can be displayed either in a graph (menu ‘plot only’), table (menu ‘data only’) or both

(menu ‘data and plot’). Optionally, a trend line is provided with the calculated trend and corresponding P -value (Fig. 3).

In case the station is present in different databases, the respective observations are colour coded (Fig. 3). Note that observations from the same station and year might have been reported in different databases with differing values. We kept all reported observations in the databases, even though in these cases the day of observation of the respective phase is ambiguous.

In the [Supplementary Material](#) we provide an additional summary table with all species–phase combinations in the combined database, which are still being observed by the German Weather Service, with their number of stations and

single stations - wild plants

 plant_name:

 phase_name:

 station_name:

 display result as: data and plot || data only || plot only

optional:

 search location:

 plot size: x pixel || max:2048px | only integer

 show trendline:

 other plant or other view:


The numbers in the circles correspond to the number of stations in this area. Zoom in to view all stations in this area.

Fig. 2 Single station perspective. Example for the phase ‘beginning of flowering’ of horse chestnut at the station ‘Geisenheim(DWD)’ (screenshot). *Balloons* indicate phenological stations. By clicking on the *balloons* some meta-information about the station is displayed

observations, and average length of time series per plant, phase and station.

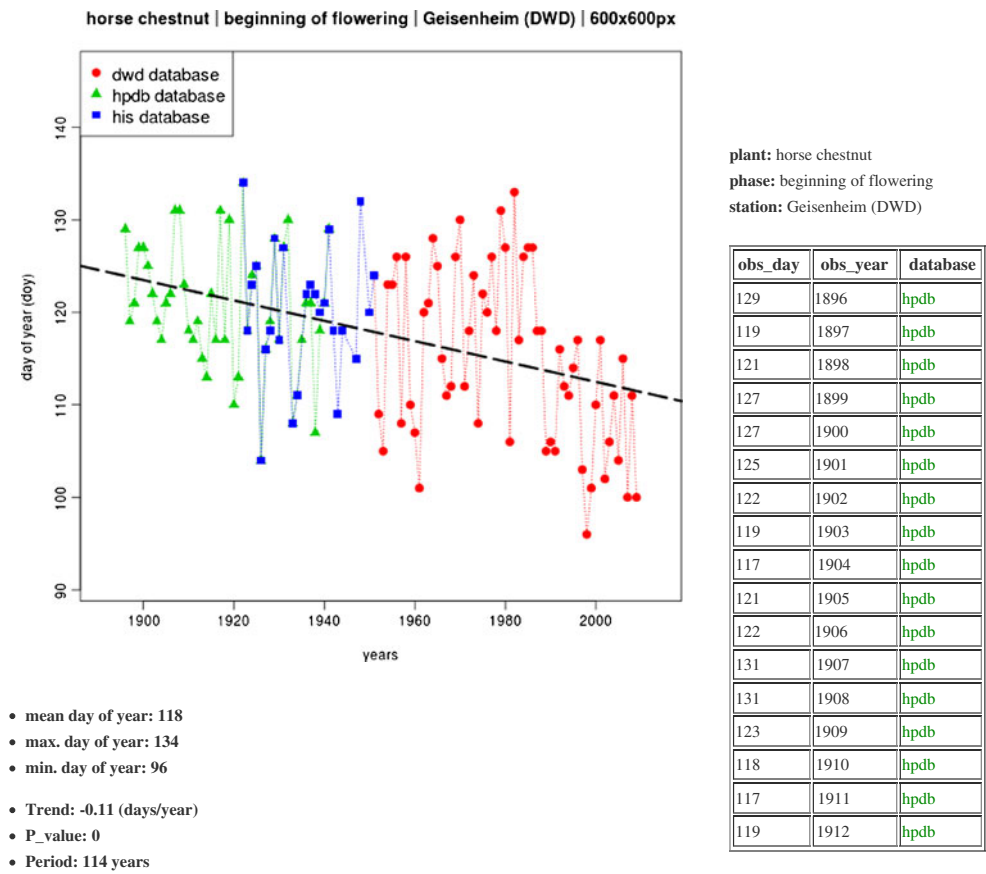
Natural regions

One of the main reasons to construct this database and to merge stations from different databases was to enable the construction of long phenological time series, so-called combined time series, in order to study the effect of climate change on plant phenology (Schaber 2002; Schaber and Badeck 2002, 2003, 2005; Schaber et al. 2010). A combined time series is a sophisticated average over many time series

that corrects for artefacts introduced by simple averages due to the unequal distribution of observations in time and space (Schaber et al. 2010). In Fig. 4 we show histograms of the number of time series of a certain length for single stations and Natural Regions, respectively. For Natural Regions, there is a substantial increase of long time series at the expense of short time series. There are more than 480 combined time series for certain phenological phases for certain Natural Regions covering more than 100 years.

Selecting the Natural Regions perspective in the start menu (Fig. 1), the user is presented an interface, where plant, phase and Natural Region can be selected (Fig. 5).

Fig. 3 Plot of the time series for the phase ‘beginning of flowering’ of horse chestnut at the station ‘Geisenheim(DWD)’. The colour code of the data points indicates the source of the corresponding observation (screenshot), which is also displayed in the corresponding table



Again plant, phase and Natural Regions can be selected by drop down menus. Natural Regions can also

be selected by clicking on the map. From this perspective, combined time series with error bars can be

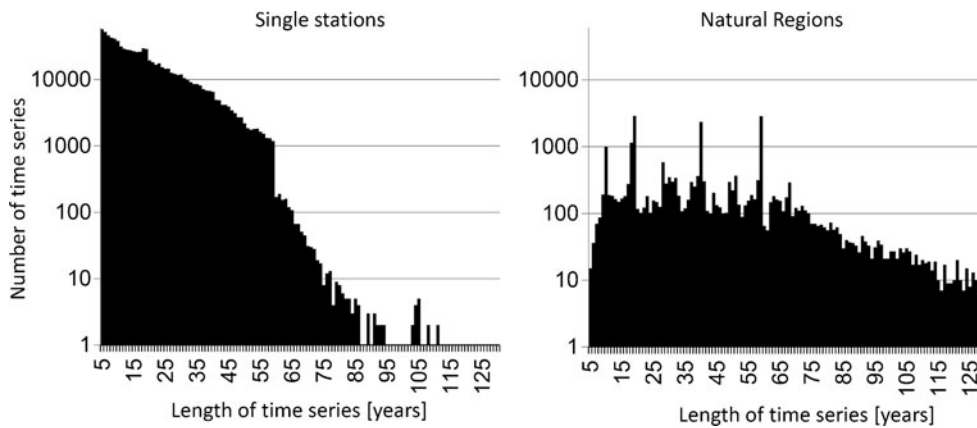


Fig. 4 Histograms of the number of time series per length of time series over all species, phases and single stations (*left panel*) and Natural Regions (*right panel*), respectively. The corresponding data can be retrieved from the database with the following SQL-queries (*left panel*): “select c, count(c) from (select stat_id, phase_id, count(distinct

obs_year) as c from all_pheno_obs where phase_id != 0 group by stat_id, phase_id) as sq group by c”, and (*right panel*): “select c, count(c) from (select naturraumgruppen_id, phase_id, count(distinct obs_year) as c from pheno_nr_ts group by naturraumgruppen_id, phase_id) as sq group by c”

natural regions - wild plants

plant_name:

phase_name:

naturraum_name:

display result as: data and plot || data only || plot only

optional:

search location:

plot size: x pixel || max:2048px | only integer

show trendline:

other plant or view:

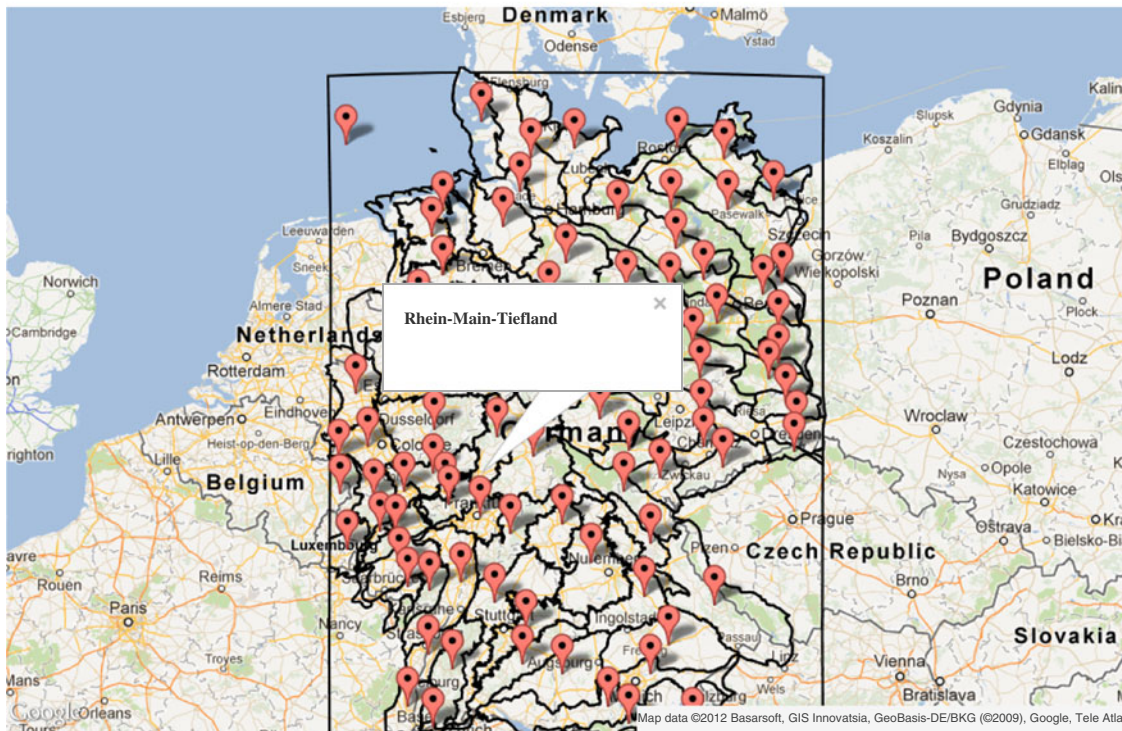


Fig. 5 Natural Regions perspective. Example for the phase ‘bud burst of beech in the Natural Region Rhein-Main Tiefland’ (screenshot). *Balloons* indicate the geographical centre of the respective Natural Region. By clicking balloons the name of Natural Region is displayed

displayed (Fig. 6). Again, a trend can be optionally displayed.

The origin of the combined data is colour-coded as above with the extension that an estimated combined data point can come from more than one database. In the corresponding table the number of observations for each combined data point is also displayed.

SQL access

Through the ‘SQL access’-tab (see Fig. 1), the database can be accessed via SQL statements that allow all kinds of individual queries. The data for Fig. 4, e.g., can be extracted

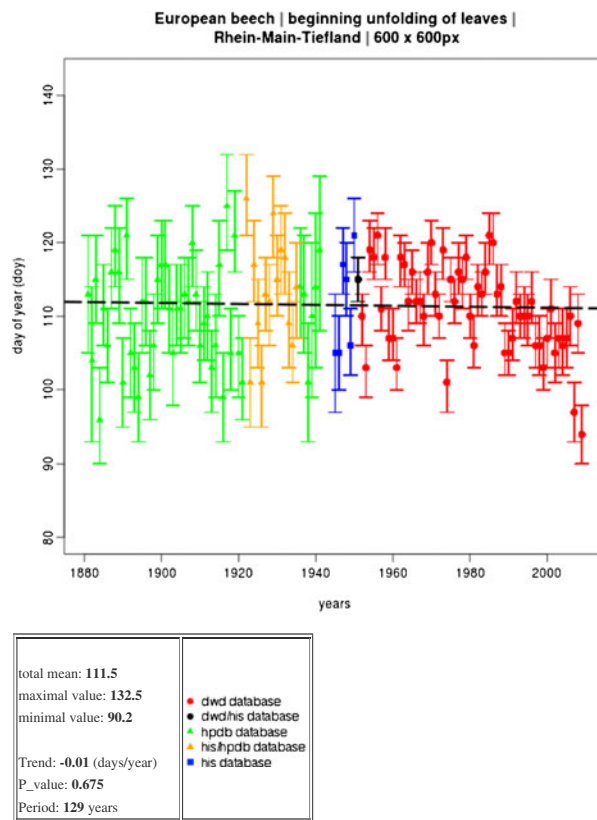
by one single SQL statement (see Fig. 4). For the summary Tables S1–S3 we also provide the respective SQL-statements as an example of the flexibility and range of queries.

Discussion

The joint databases made available with *PPODB* render accessible an important data source for further analyses of long-term changes in phenology.

The database is unique in as far as it covers more than a century of observations for a large geographical region and

Fig. 6 Plot of the time series for the phase bud burst of beech in the Natural Region ‘Rhein-Main-Tiefland’. The colour code of the data points indicates the source of the corresponding observation (screenshot). The error bars are the lower and upper 95 % confidence levels of the estimated mean day of year (dots), which are displayed in the corresponding table (L95CL and L95UL, respectively). The number of observations per year (n_obs) in the table indicate the number of observations/stations the combined mean per year was calculated from



plant: European beech
 phase: beginning unfolding of leaves
 natural region: Rhein-Main-Tiefland

obs_year	mean doy	L95CL	U95CL	n_obs	database
1881	113.7	105.69	121.8	2	hpdb
1882	104.1	93.38	114.82	1	hpdb
1883	115.4	109.65	121.31	5	hpdb
1884	97	90.93	103	5	hpdb
1885	111.7	106.4	117.03	7	hpdb
1886	106.4	101.11	111.75	7	hpdb
1887	116.8	111.37	122.29	6	hpdb
1888	119.9	114.07	125.65	5	hpdb
1889	116.2	109.47	122.92	3	hpdb
1890	101.4	95.28	107.57	4	hpdb
1891	121.2	115.5	126.94	5	hpdb
1892	105.8	99.65	111.85	4	hpdb
1893	103.8	97.65	109.85	4	hpdb
1894	99.8	93.65	105.85	4	hpdb
1895	112	105.9	118.1	4	hpdb
1896	112.5	106.9	118.04	5	hpdb
1897	102.9	96.93	108.9	4	hpdb
1898	106.8	100.16	113.3	3	hpdb
1899	115.7	109.77	121.71	4	hpdb
1900	117.5	111.52	123.46	4	hpdb

at the same time a substantial number of species as well as many observation stations. It complements another phenological online database, the paneuropean phenology database *PEP725* (Koch et al. 2009) (www.pep725.eu), which is also unique in the sense that it partly covers other countries than *PPODB* for which it has more contemporary data. *PEP725* observations start as early as 1868, but only for the relatively small region of the Netherlands. *PEP725* provides data retrieval with downloadable species-related observations per country, where observations, station description and phase description are provided in separate files. With *PPODB* we provide an instrument including an SQL interface to the complete database that greatly facilitates data retrieved for all kind of summary information or very specific and focussed information and can potentially be used to improve the access to the *PEP725* data base. In addition, the data of the HIS and HPDB databases can be used to construct long-term combined time series with data provided by *PEP725* for other countries, especially Poland. Moreover, the combined time series for the Natural Regions of Germany provide a unique data source of reliable long-term phenological time series for a range of species and phenological phases.

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The plant-phenological online database (PPODB): an online database for long-term phenological data

Supplementary Tables

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Table S1: Represented countries in *PPODB*, number of stations, number of observations and observational time range per country.

Country	# stations	# observations	Min. obs. year	Max. obs. year
Germany	7721	15939030	1880	2009
Poland	254	41634	1880	2007
Netherlands	63	7102	1880	1937
Switzerland	58	8733	1880	1979
Russia	41	7340	1880	1944
Hungary	36	6346	1881	1941
Austria	28	21529	1880	2009
France	18	3168	1881	1952
United Kingdom	17	3095	1880	1938
Italy	15	1764	1882	1940
Belgium	11	889	1883	1918
Ukraine	11	3830	1882	1935
Czechia	10	11243	1880	2009
Romania	8	782	1910	1917
Finland	5	31	1883	1883
Serbia	4	977	1898	1941
Latvia	3	83	1880	1883
Portugal	3	1627	1882	1912
Luxembourg	3	3605	1931	1973
Spain	3	38	1880	1914
Norway	2	451	1917	1936
Slovakia	2	102	1910	1916
Slovenia	2	264	1880	1919
Denmark	2	1308	1882	1906
Estonia	2	166	1882	1887
United States	2	149	1898	1901
Faroe Islands	2	73	1897	1901
Ireland	2	41	1891	1895
Turkey	1	41	1910	1911
Georgia	1	16	1895	1895
Montenegro	1	11	1916	1916
Sweden	1	32	1884	1886
Belarus	1	16	1917	1917

This table was retrieved from the database with the following query: “select country, count(distinct a.stat_id) c_stat, count(*) c_obs, min(obs_year), max(obs_year) from pheno_stations a, all_pheno_obs b where a.stat_id=b.stat_id group by country order by c_stat desc”

Table S2: All species-phase combination in the combined database, which are still being observed by the German Weather Service, with their number of stations and observations, and average length of time series per plant, phase and station. Only time series with more than 5 observations are considered. Grouped by plant type and descending length of time series.

Plant Type	Phase Id	Plant name (latin)	Phase name	# Stations	# Observations	Average length of time series [years]
wild	126	<i>Abies alba</i>	beginning of flowering	1437	19770	13.8
wild	127	<i>Abies alba</i>	beginning of may sprouting	2453	38007	15.5
wild	5	<i>Acer platanoides</i>	beginning of flowering	4182	93145	22.3
wild	224	<i>Aesculus hippocastanum</i>	leaf fall	2431	32291	13.3
wild	8	<i>Aesculus hippocastanum</i>	beginning of flowering	5839	146920	25.2
wild	223	<i>Aesculus hippocastanum</i>	beginning of sprouting	2097	29363	14.0
wild	7	<i>Aesculus hippocastanum</i>	beginning unfolding of leaves	5798	147915	25.5
wild	69	<i>Aesculus hippocastanum</i>	colouring of leaves	5467	135850	24.8
wild	68	<i>Aesculus hippocastanum</i>	first ripe fruits	5440	134599	24.7
wild	112	<i>Alnus glutinosa</i>	beginning of flowering	3639	77681	21.3
wild	113	<i>Alnus glutinosa</i>	beginning unfolding of leaves	3874	82473	21.3
wild	227	<i>Alopecurus pratensis</i>	beginning of flowering	1885	26073	13.8
wild	19	<i>Alopecurus pratensis</i>	flowering general blossom	4555	107030	23.5
wild	115	<i>Anemone nemorosa</i>	beginning of flowering	4748	118348	24.9
wild	213	<i>Artemisia vulgaris</i>	beginning of flowering	1542	20436	13.3
wild	219	<i>Betula pendula</i>	beginning of sprouting	2052	28309	13.8
wild	74	<i>Betula pendula</i>	colouring of leaves	5153	130544	25.3
wild	221	<i>Betula pendula</i>	leaf fall	2372	32228	13.6
wild	220	<i>Betula pendula</i>	beginning of flowering	2382	32259	13.5
wild	9	<i>Betula pendula</i>	beginning unfolding of leaves	5389	139369	25.9
wild	65	<i>Calluna vulgaris</i>	beginning of flowering	4260	96511	22.7
wild	66	<i>Colchicum autumnale</i>	beginning of flowering	3107	56525	18.2
wild	222	<i>Cornus mas</i>	first ripe fruits	1097	13972	12.7
wild	114	<i>Cornus mas</i>	Beginning of flowering	2637	54504	20.7
wild	1	<i>Corylus avellana</i>	beginning of flowering	4810	113554	23.6
wild	228	<i>Crataegus laevigata</i>	first ripe fruits	1627	21795	13.4
wild	16	<i>Crataegus laevigata</i>	beginning of flowering	4648	111849	24.1
wild	20	<i>Dactylis glomerata</i>	flowering general blossom	4616	111582	24.2
wild	71	<i>Fagus sylvatica</i>	colouring of leaves	4711	111881	23.7
wild	70	<i>Fagus sylvatica</i>	first ripe fruits	2589	39677	15.3
wild	12	<i>Fagus sylvatica</i>	beginning unfolding of leaves	4886	115997	23.7
wild	124	<i>Fagus sylvatica</i>	beginning of flowering	2243	31849	14.2
wild	225	<i>Fagus sylvatica</i>	leaf fall	2069	28422	13.7
wild	6	<i>Forsythia suspensa</i>	beginning of flowering	4200	103901	24.7
wild	120	<i>Fraxinus excelsior</i>	beginning unfolding of leaves	3952	85076	21.5
wild	119	<i>Fraxinus excelsior</i>	beginning of flowering	3469	69616	20.1
wild	2	<i>Galanthus nivalis</i>	beginning of flowering	5941	155737	26.2
wild	133	<i>Laburnum anagyroides</i>	beginning of flowering	3480	63542	18.3
wild	218	<i>Larix decidua</i>	needle fall	1907	25732	13.5
wild	217	<i>Larix decidua</i>	colouring of needles	1922	26171	13.6

wild	118	<i>Larix decidua</i>	beginning of flowering	2530	38340	15.2
wild	117	<i>Larix decidua</i>	beginning unfolding of leaves	4044	92749	22.9
wild	134	<i>Philadelphus coronarius</i>	beginning of flowering	2885	43086	14.9
wild	17	<i>Picea abies</i>	beginning of may sprouting	4705	112488	23.9
wild	125	<i>Picea abies</i>	beginning of flowering	2172	31417	14.5
wild	129	<i>Pinus sylvestris</i>	beginning of may sprouting	4060	85175	21.0
wild	128	<i>Pinus sylvestris</i>	beginning of flowering	3403	67845	19.9
wild	130	<i>Prunus padus</i>	beginning of flowering	2096	33994	16.2
wild	11	<i>Prunus spinosa</i>	beginning of flowering	4548	106730	23.5
wild	176	<i>Quercus robur</i>	St. John's sprouts	1664	22784	13.7
wild	13	<i>Quercus robur</i>	beginning unfolding of leaves	4812	116826	24.3
wild	226	<i>Quercus robur</i>	leaf fall	2067	28058	13.6
wild	73	<i>Quercus robur</i>	colouring of leaves	4869	117484	24.1
wild	72	<i>Quercus robur</i>	first ripe fruits	4335	95974	22.1
wild	14	<i>Quercus robur</i>	beginning of flowering	3525	58223	16.5
wild	123	<i>Robinia pseudoacacia</i>	beginning of flowering	3891	85134	21.9
wild	122	<i>Robinia pseudoacacia</i>	beginning unfolding of leaves	2510	42167	16.8
wild	132	<i>Rosa canina</i>	beginning of flowering	4306	98922	23.0
wild	177	<i>Rosa canina</i>	first ripe fruits	3954	86514	21.9
wild	4	<i>Salix caprea</i>	beginning of flowering	5421	139377	25.7
wild	67	<i>Sambucus nigra</i>	first ripe fruits	5362	135412	25.3
wild	18	<i>Sambucus nigra</i>	beginning of flowering	5891	146374	24.8
wild	214	<i>Sorbus aucuparia</i>	beginning of sprouting	2013	27536	13.7
wild	178	<i>Sorbus aucuparia</i>	first ripe fruits	4269	95398	22.3
wild	216	<i>Sorbus aucuparia</i>	leaf fall	1863	24768	13.3
wild	131	<i>Sorbus aucuparia</i>	beginning of flowering	4064	90791	22.3
wild	215	<i>Sorbus aucuparia</i>	beginning unfolding of leaves	2017	27910	13.8
wild	135	<i>Symphoricarpos albus</i>	beginning of flowering	2706	43597	16.1
wild	15	<i>Syringa vulgaris</i>	beginning of flowering	5974	153001	25.6
wild	116	<i>Taraxacum officinale</i>	Beginning of flowering	5279	138370	26.2
wild	121	<i>Tilia cordata</i>	beginning unfolding of leaves	3180	55512	17.5
wild	175	<i>Tilia cordata</i>	beginning of flowering	3453	57752	16.7
wild	64	<i>Tilia platyphyllos</i>	beginning of flowering	5216	121654	23.3
wild	10	<i>Tilia platyphyllos</i>	beginning unfolding of leaves	4498	83505	18.6
wild	3	<i>Tussilago farfara</i>	beginning of flowering	5247	127392	24.3
agro	22	<i>Avena sativa</i>	emergence	4818	108214	22.5
agro	195	<i>Avena sativa</i>	beginning of harvest by combine	3516	73643	20.9
agro	21	<i>Avena sativa</i>	tilling, sowing, drilling	4977	112468	22.6
agro	97	<i>Avena sativa</i>	beginning of full ripeness	2416	40077	16.6
agro	96	<i>Avena sativa</i>	harvest	3511	48595	13.8
agro	24	<i>Avena sativa</i>	beginning of tassel emergence	4340	93156	21.5
agro	95	<i>Avena sativa</i>	beginning of yellow ripeness	3247	65227	20.1
agro	23	<i>Avena sativa</i>	beginning of growth in height	3754	77100	20.5
agro	235	<i>Avena sativa</i>	beginning of milk ripeness	1175	14939	12.7
agro	291	<i>Beta vulgaris</i>	closed stand	24	211	8.8
agro	290	<i>Beta vulgaris</i>	emergence	295	3483	11.8
agro	289	<i>Beta vulgaris</i>	tilling, sowing, drilling	27	251	9.3
agro	292	<i>Beta vulgaris</i>	harvest	26	238	9.2
agro	44	<i>Beta vulgaris</i> var. <i>Altissima</i>	closed stand	1686	32861	19.5

agro	43	Beta vulgaris var. Altissima	emergence	2207	42590	19.3
agro	42	Beta vulgaris var. Altissima	tilling, sowing, drilling	2266	44049	19.4
agro	99	Beta vulgaris var. Altissima	harvest	2325	44490	19.1
agro	45	Beta vulgaris var. crassa	emergence	3986	74779	18.8
agro	98	Beta vulgaris var. crassa	harvest	4691	92488	19.7
agro	151	Beta vulgaris var. crassa	closed stand	2396	41082	17.1
agro	150	Beta vulgaris var. crassa	tilling, sowing, drilling	3468	64153	18.5
agro	249	Brassica napus, var. Napus	beginning of growth in height	1156	15058	13.0
agro	144	Brassica napus, var. Napus	beginning of flowering	2979	56515	19.0
agro	252	Brassica napus, var. Napus	beginning of rosette formation	1057	13858	13.1
agro	183	Brassica napus, var. Napus	emergence	2675	48409	18.1
agro	251	Brassica napus, var. Napus	beginning of full ripeness	1192	15714	13.2
agro	182	Brassica napus, var. Napus	tilling, sowing, drilling	2424	41984	17.3
agro	250	Brassica napus, var. Napus	beginning of bud formation	1209	16151	13.4
agro	181	Brassica napus, var. Napus	harvest	2771	49870	18.0
agro	200	Brassica oleracea var. capitat	harvest	1477	22388	15.2
agro	160	Brassica oleracea var. capitat	beginning of planting	1455	21266	14.6
agro	244	Helianthus annuus	emergence	344	3918	11.4
agro	248	Helianthus annuus	harvest	325	3771	11.6
agro	243	Helianthus annuus	tilling, sowing, drilling	335	3872	11.6
agro	247	Helianthus annuus	beginning of flowering	351	4054	11.5
agro	246	Helianthus annuus	beginning of bud formation	307	3532	11.5
agro	245	Helianthus annuus	beginning unfolding of leaves	313	3577	11.4
agro	191	Hordeum vulgare	beginning of harvest by combine	3658	79389	21.7
agro	27	Hordeum vulgare	beginning of growth in height	2841	46853	16.5
agro	36	Hordeum vulgare	beginning of heading	3283	68775	20.9
agro	80	Hordeum vulgare	tilling, sowing, drilling	3396	72783	21.4
agro	84	Hordeum vulgare	beginning of full ripeness	2258	36808	16.3
agro	26	Hordeum vulgare	emergence	4134	78731	19.0
agro	35	Hordeum vulgare	beginning of growth in height	3051	61719	20.2
agro	79	Hordeum vulgare	beginning of full ripeness	2169	33446	15.4
agro	83	Hordeum vulgare	harvest	2792	37917	13.6
agro	25	Hordeum vulgare	tilling, sowing, drilling	3803	68550	18.0
agro	78	Hordeum vulgare	harvest	2274	28493	12.5
agro	82	Hordeum vulgare	beginning of yellow ripeness	2581	40274	15.6
agro	77	Hordeum vulgare	beginning of yellow ripeness	2925	58845	20.1
agro	192	Hordeum vulgare	beginning of harvest by combine	3436	56776	16.5
agro	28	Hordeum vulgare	beginning of heading	3487	60435	17.3
agro	81	Hordeum vulgare	emergence	3325	70735	21.3
agro	185	Medicago sativa	2. cut for hay	1415	21273	15.0
agro	162	Medicago sativa	1. cut for hay	1530	23465	15.3

agro	157	Phaseolus vulgaris	beginning of flowering	1397	16539	11.8
agro	156	Phaseolus vulgaris	emergence	1841	25986	14.1
agro	198	Phaseolus vulgaris	harvest	1907	26544	13.9
agro	155	Phaseolus vulgaris	tilling, sowing, drilling	1914	27153	14.2
agro	153	Pisum sativa	emergence	1695	23769	14.0
agro	152	Pisum sativa	tilling, sowing, drilling	1755	24703	14.1
agro	197	Pisum sativa	harvest	1684	23171	13.8
agro	154	Pisum sativa	beginning of flowering	1610	22117	13.7
agro	89	Secale cereale	emergence	4479	94998	21.2
agro	253	Secale cereale	beginning of flowering	3526	51048	14.5
agro	88	Secale cereale	tilling, sowing, drilling	4466	97214	21.8
agro	39	Secale cereale	full blossom	3408	66212	19.4
agro	87	Secale cereale	beginning of full ripeness	2212	35582	16.1
agro	193	Secale cereale	beginning of harvest by combine	3668	75051	20.5
agro	38	Secale cereale	beginning of heading	4453	97675	21.9
agro	86	Secale cereale	harvest	3792	53194	14.0
agro	37	Secale cereale	beginning of shooting	4133	82499	20.0
agro	85	Secale cereale	beginning of yellow ripeness	3052	58468	19.2
agro	158	Solanum lycopersicum	beginning of planting	2183	28597	13.1
agro	199	Solanum lycopersicum	harvest	2035	26185	12.9
agro	159	Solanum lycopersicum	beginning of flowering	1891	23847	12.6
agro	31	Solanum tuberosum	closed stand	2454	40738	16.6
agro	75	Solanum tuberosum	beginning of flowering	4098	71355	17.4
agro	180	Solanum tuberosum	harvest	3053	49156	16.1
agro	148	Solanum tuberosum	beginning of flowering	1532	20295	13.2
agro	30	Solanum tuberosum	emergence	3079	51562	16.7
agro	179	Solanum tuberosum	harvest	1843	26143	14.2
agro	147	Solanum tuberosum	closed stand	1472	21320	14.5
agro	34	Solanum tuberosum	closed stand	2845	49450	17.4
agro	29	Solanum tuberosum	tilling, sowing, drilling	3244	54867	16.9
agro	146	Solanum tuberosum	emergence	1784	25324	14.2
agro	33	Solanum tuberosum	emergence	4367	82291	18.8
agro	145	Solanum tuberosum	tilling, sowing, drilling	1861	26583	14.3
agro	32	Solanum tuberosum	tilling, sowing, drilling	4616	89932	19.5
agro	76	Solanum tuberosum	harvest	4683	87989	18.8
agro	149	Solanum tuberosum	beginning of flowering	2607	38057	14.6
agro	184	Trifolium pratense	2. cut for hay	1849	25841	14.0
agro	161	Trifolium pratense	1. cut for hay	2184	30072	13.8
agro	94	Triticum aestivum	emergence	3989	87881	22.0
agro	40	Triticum aestivum	beginning of shooting	3335	70589	21.2
agro	139	Triticum aestivum	beginning of heading	1867	26552	14.2
agro	190	Triticum aestivum	beginning of harvest by combine	1476	21641	14.7
agro	93	Triticum aestivum	tilling, sowing, drilling	4175	96323	23.1
agro	194	Triticum aestivum	beginning of harvest by combine	3585	76913	21.5
agro	138	Triticum aestivum	beginning of growth in height	1663	23379	14.1
agro	189	Triticum aestivum	beginning of full ripeness	1278	18006	14.1
agro	92	Triticum aestivum	beginning of full ripeness	2284	37659	16.5
agro	137	Triticum aestivum	emergence	2100	31301	14.9
agro	188	Triticum aestivum	harvest	1381	16554	12.0
agro	91	Triticum aestivum	harvest	3002	41698	13.9
agro	136	Triticum aestivum	tilling, sowing, drilling	2176	32644	15.0
agro	187	Triticum aestivum	beginning of yellow ripeness	1481	19996	13.5
agro	90	Triticum aestivum	beginning of yellow ripeness	3056	62555	20.5
agro	41	Triticum aestivum	beginning of heading	3655	81525	22.3
agro	254	Triticum aestivum	beginning of milk	1291	16985	13.2

			ripeness			
agro	239	Zea mays	beginning of milk ripeness	1010	11191	11.1
agro	302	Zea mays	beginning of yellow ripeness	339	3288	9.7
agro	297	Zea mays	beginning of shooting	299	2596	8.7
agro	238	Zea mays	beginning of flowering	1093	12314	11.3
agro	143	Zea mays	full blossom	462	4303	9.3
agro	301	Zea mays	beginning of wax-ripe stage	332	2752	8.3
agro	296	Zea mays	emergence	429	3801	8.9
agro	237	Zea mays	beginning of shooting	1158	12591	10.9
agro	142	Zea mays	beginning of tassel emergence	1547	21699	14.0
agro	300	Zea mays	beginning of milk ripeness	285	2451	8.6
agro	241	Zea mays	beginning of yellow ripeness	850	8704	10.2
agro	295	Zea mays	tilling, sowing, drilling	409	3614	8.8
agro	236	Zea mays	FAO index	1230	10780	8.8
agro	141	Zea mays	emergence	2451	45217	18.4
agro	299	Zea mays	beginning of flowering	326	2833	8.7
agro	240	Zea mays	beginning of wax-ripe stage	969	10695	11.0
agro	303	Zea mays	harvest	699	6396	9.2
agro	196	Zea mays	harvest	2470	43584	17.6
agro	140	Zea mays	tilling, sowing, drilling	2474	45779	18.5
agro	298	Zea mays	beginning of tassel emergence	337	2941	8.7
fruit	168	Fragaria	beginning of flowering	3729	66400	17.8
fruit	202	Fragaria	fruit ripe for picking	3619	63546	17.6
fruit	307	Malus domestica	end of flowering	227	2271	10.0
fruit	62	Malus domestica	beginning of flowering	5506	132657	24.1
fruit	167	Malus domestica	full flowering	4280	92628	21.6
fruit	260	Malus domestica	beginning of flowering	1730	22070	12.8
fruit	311	Malus domestica	beginning of flowering	228	2160	9.5
fruit	306	Malus domestica	full flowering	244	2418	9.9
fruit	315	Malus domestica	leaf fall	154	1473	9.6
fruit	111	Malus domestica	fruit ripe for picking	4637	103513	22.3
fruit	259	Malus domestica	beginning of sprouting	1833	22150	12.1
fruit	310	Malus domestica	beginning of sprouting	173	1672	9.7
fruit	263	Malus domestica	leaf fall	1510	18566	12.3
fruit	305	Malus domestica	beginning of flowering	332	3660	11.0
fruit	314	Malus domestica	fruit ripe for picking	185	1785	9.6
fruit	110	Malus domestica	fruit ripe for picking	3770	60451	16.0
fruit	257	Malus domestica	leaf fall	1364	16870	12.4
fruit	309	Malus domestica	leaf fall	151	1547	10.2
fruit	262	Malus domestica	end of flowering	1713	21336	12.5
fruit	304	Malus domestica	beginning of sprouting	289	3326	11.5
fruit	313	Malus domestica	end of flowering	199	1928	9.7
fruit	109	Malus domestica	fruit ripe for picking	4270	91449	21.4
fruit	256	Malus domestica	beginning of sprouting	1427	18258	12.8
fruit	308	Malus domestica	fruit ripe for picking	198	2025	10.2
fruit	63	Malus domestica	end of flowering	4146	88256	21.3
fruit	261	Malus domestica	full flowering	1679	21275	12.7
fruit	312	Malus domestica	full flowering	210	2020	9.6
fruit	49	Prunus armeniaca	beginning of flowering	896	13098	14.6
fruit	270	Prunus avium	leaf fall	1214	15301	12.6
fruit	103	Prunus avium	fruit ripe for picking	3744	67632	18.1
fruit	320	Prunus avium	beginning of flowering	644	7400	11.5
fruit	102	Prunus avium	fruit ripe for picking	3701	67287	18.2
fruit	324	Prunus avium	leaf fall	449	4894	10.9
fruit	55	Prunus avium	end of flowering	3963	84379	21.3
fruit	322	Prunus avium	end of flowering	592	6777	11.4
fruit	54	Prunus avium	beginning of flowering	5170	121013	23.4

fruit	163	Prunus avium	full flowering	4079	86776	21.3
fruit	321	Prunus avium	full flowering	619	7097	11.5
fruit	57	Prunus cerasus	end of flowering	3980	83420	21.0
fruit	56	Prunus cerasus	beginning of flowering	4950	114004	23.0
fruit	164	Prunus cerasus	full flowering	4110	86942	21.2
fruit	104	Prunus cerasus	fruit ripe for picking	4561	99691	21.9
fruit	106	Prunus domestica	fruit ripe for picking	4186	71456	17.1
fruit	165	Prunus domestica	full flowering	3522	64363	18.3
fruit	105	Prunus domestica	fruit ripe for picking	3505	56277	16.1
fruit	59	Prunus domestica	end of flowering	3401	61521	18.1
fruit	58	Prunus domestica	beginning of flowering	4714	90086	19.1
fruit	50	Prunus persica	beginning of flowering	2518	40304	16.0
fruit	316	Pyrus communis	beginning of flowering	404	4270	10.6
fruit	107	Pyrus communis	fruit ripe for picking	3676	65193	17.7
fruit	61	Pyrus communis	end of flowering	3958	83615	21.1
fruit	166	Pyrus communis	full flowering	4093	87471	21.4
fruit	319	Pyrus communis	fruit ripe for picking	274	2797	10.2
fruit	60	Pyrus communis	beginning of flowering	5338	125796	23.6
fruit	318	Pyrus communis	end of flowering	355	3727	10.5
fruit	317	Pyrus communis	full flowering	378	3994	10.6
fruit	108	Pyrus communis	fruit ripe for picking	3936	71011	18.0
fruit	51	Ribes rubrum	beginning of flowering	5401	125941	23.3
fruit	100	Ribes rubrum	fruit ripe for picking	5238	122613	23.4
fruit	52	Ribes uva-crispa	beginning unfolding of leaves	4979	118389	23.8
fruit	268	Ribes uva-crispa	beginning of sprouting	1881	25628	13.6
fruit	101	Ribes uva-crispa	fruit ripe for picking	4801	113034	23.5
fruit	53	Ribes uva-crispa	beginning of flowering	5324	129644	24.4
fruit	170	Rubus	beginning of flowering	2438	36882	15.1
fruit	204	Rubus	fruit ripe for picking	2690	42092	15.6
fruit	169	Rubus idaeus	beginning of flowering	3074	51249	16.7
fruit	203	Rubus idaeus	first ripe fruits	3259	56325	17.3
vine	281	Vitis vinifera	full flowering	117	1625	13.9
vine	210	Vitis vinifera	leaf fall	195	2887	14.8
vine	275	Vitis vinifera	colouring of leaves	151	1998	13.2
vine	171	Vitis vinifera	beginning of sprouting	474	9409	19.9
vine	205	Vitis vinifera	grape gathering	351	7113	20.3
vine	285	Vitis vinifera	altitude of vineyard (m)	158	2132	13.5
vine	280	Vitis vinifera	beginning of flowering	119	1673	14.1
vine	209	Vitis vinifera	leaf fall	330	6359	19.3
vine	274	Vitis vinifera	beginning of ripening	150	1965	13.1
vine	284	Vitis vinifera	colouring of leaves	110	1518	13.8
vine	279	Vitis vinifera	beginning unfolding of leaves	117	1636	14.0
vine	174	Vitis vinifera	end of flowering	347	6478	18.7
vine	208	Vitis vinifera	grape gathering	125	1704	13.6
vine	273	Vitis vinifera	beginning unfolding of leaves	157	2117	13.5
vine	283	Vitis vinifera	beginning of ripening	112	1514	13.5
vine	212	Vitis vinifera	leaf fall	96	1211	12.6
vine	278	Vitis vinifera	beginning of sprouting	113	1552	13.7
vine	173	Vitis vinifera	full flowering	409	8160	20.0
vine	207	Vitis vinifera	grape gathering	263	5126	19.5
vine	287	Vitis vinifera	altitude of vineyard (m)	121	1699	14.0
vine	272	Vitis vinifera	first bleeding of the vines	147	1959	13.3
vine	282	Vitis vinifera	end of flowering	114	1585	13.9
vine	211	Vitis vinifera	leaf fall	223	4169	18.7
vine	277	Vitis vinifera	first bleeding of the vines	108	1489	13.8
vine	172	Vitis vinifera	beginning of flowering	436	8939	20.5
vine	206	Vitis vinifera	grape gathering	238	3717	15.6
vine	286	Vitis vinifera	index vintage method/exposition/ inklination	142	1346	9.5

This table was retrieved from the database with the following query: “select pt, pid, pnl, pne, phne, count(*) c, sum(c), avg(c) from (select plant_type pt, stat_id sid, a.phase_id pid, plant_name_la pnl, plant_name_en pne, phase_name_en phne, count(*) c from all_pheno_obs a, dwd_pheno_def b where a.phase_id=b.phase_id group by a.phase_id,stat_id having c > 5) as st where pnl!='NULL' group by pt, pid order by pt,pnl;”

Table S3: All species-phase combination in the combined database, which are still being observed by the German Weather Service, with their number of stations and observations, and average length of time series per plant, phase and station. Only time series with more than 5 observations are considered. Grouped by plant type and descending length of time series.

Plant Type	Phase Id	Plant name (latin)	Phase name	Average length of time series	Min year	Max year	Max length of time series [years]
wild	8	Aesculus hippocastanum	beginning of flowering	91.5	1880	2009	130
wild	12	Fagus sylvatica	beginning unfolding of leaves	80.4	1880	2009	130
wild	67	Sambucus nigra	first ripe fruits	79.9	1880	2009	130
wild	71	Fagus sylvatica	colouring of leaves	75.4	1880	2009	130
wild	113	Alnus glutinosa	beginning unfolding of leaves	58.0	1880	2009	130
wild	216	Sorbus aucuparia	leaf fall	19.0	1880	2009	130
wild	220	Betula pendula	beginning of flowering	34.8	1880	2009	130
wild	224	Aesculus hippocastanum	leaf fall	24.0	1880	2009	130
wild	7	Aesculus hippocastanum	beginning unfolding of leaves	90.4	1880	2009	130
wild	15	Syringa vulgaris	beginning of flowering	91.5	1880	2009	130
wild	74	Betula pendula	colouring of leaves	73.9	1880	2009	130
wild	112	Alnus glutinosa	beginning of flowering	54.8	1880	2009	130
wild	116	Taraxacum officinale	Beginning of flowering	59.1	1880	2009	130
wild	128	Pinus sylvestris	beginning of flowering	54.1	1880	2009	130
wild	215	Sorbus aucuparia	beginning unfolding of leaves	20.1	1880	2009	130
wild	219	Betula pendula	beginning of sprouting	33.1	1880	2009	130
wild	223	Aesculus hippocastanum	beginning of sprouting	34.7	1880	2009	130
wild	2	Galanthus nivalis	beginning of flowering	85.9	1880	2009	130
wild	18	Sambucus nigra	beginning of flowering	88.7	1880	2009	130
wild	69	Aesculus hippocastanum	colouring of leaves	85.4	1880	2009	130
wild	119	Fraxinus excelsior	beginning of flowering	60.4	1880	2009	130
wild	123	Robinia pseudoacacia	beginning of flowering	68.7	1880	2009	130
wild	131	Sorbus aucuparia	beginning of flowering	67.5	1880	2009	130
wild	214	Sorbus aucuparia	beginning of sprouting	20.0	1880	2009	130
wild	1	Corylus avellana	beginning of flowering	66.2	1880	2009	130
wild	9	Betula pendula	beginning unfolding of leaves	80.8	1880	2009	130
wild	13	Quercus robur	beginning unfolding of leaves	75.9	1880	2009	130
wild	64	Tilia platyphyllos	beginning of flowering	87.6	1880	2009	130
wild	68	Aesculus hippocastanum	first ripe fruits	85.9	1880	2009	130
wild	178	Sorbus aucuparia	first ripe fruits	63.3	1880	2009	130
wild	221	Betula pendula	leaf fall	24.2	1880	2009	130
wild	225	Fagus sylvatica	leaf fall	23.5	1880	2009	130
wild	120	Fraxinus excelsior	beginning unfolding of leaves	64.2	1881	2009	129
wild	72	Quercus robur	first ripe fruits	61.6	1881	2009	129
wild	73	Quercus robur	colouring of leaves	75.7	1882	2009	128
wild	226	Quercus robur	leaf fall	23.3	1882	2009	128
wild	3	Tussilago farfara	beginning of flowering	75.0	1886	2009	124
wild	65	Calluna vulgaris	beginning of flowering	73.6	1891	2009	119

wild	121	<i>Tilia cordata</i>	beginning unfolding of leaves	40.7	1880	1990	111
wild	133	<i>Laburnum anagyroides</i>	beginning of flowering	51.3	1880	1990	111
wild	124	<i>Fagus sylvatica</i>	beginning of flowering	33.7	1880	1990	111
wild	175	<i>Tilia cordata</i>	beginning of flowering	49.8	1880	1990	111
wild	10	<i>Tilia platyphyllos</i>	beginning unfolding of leaves	49.2	1880	1990	111
wild	135	<i>Symphoricarpos albus</i>	beginning of flowering	46.0	1880	1990	111
wild	122	<i>Robinia pseudoacacia</i>	beginning unfolding of leaves	34.2	1880	1990	111
wild	130	<i>Prunus padus</i>	beginning of flowering	46.5	1880	1990	111
wild	134	<i>Philadelphus coronarius</i>	beginning of flowering	35.2	1880	1990	111
wild	70	<i>Fagus sylvatica</i>	first ripe fruits	34.8	1881	1990	110
wild	14	<i>Quercus robur</i>	beginning of flowering	39.4	1881	1990	110
wild	20	<i>Dactylis glomerata</i>	flowering general blossom	59.5	1902	2009	108
wild	118	<i>Larix decidua</i>	beginning of flowering	35.6	1883	1990	108
wild	125	<i>Picea abies</i>	beginning of flowering	34.8	1886	1990	105
wild	11	<i>Prunus spinosa</i>	beginning of flowering	59.5	1921	2009	89
wild	4	<i>Salix caprea</i>	beginning of flowering	69.2	1922	2009	88
wild	129	<i>Pinus sylvestris</i>	beginning of may sprouting	60.5	1922	2009	88
wild	17	<i>Picea abies</i>	beginning of may sprouting	67.9	1922	2009	88
wild	16	<i>Crataegus laevigata</i>	beginning of flowering	57.9	1923	2009	87
wild	19	<i>Alopecurus pratensis</i>	flowering general blossom	59.3	1936	2009	74
wild	5	<i>Acer platanoides</i>	beginning of flowering	61.2	1936	2009	74
wild	66	<i>Colchicum autumnale</i>	beginning of flowering	43.7	1922	1990	69
wild	127	<i>Abies alba</i>	beginning of may sprouting	37.4	1922	1990	69
wild	114	<i>Cornus mas</i>	Beginning of flowering	52.3	1945	2009	65
wild	117	<i>Larix decidua</i>	beginning unfolding of leaves	51.0	1951	2009	59
wild	177	<i>Rosa canina</i>	first ripe fruits	50.7	1951	2009	59
wild	132	<i>Rosa canina</i>	beginning of flowering	51.0	1951	2009	59
wild	227	<i>Alopecurus pratensis</i>	beginning of flowering	19.0	1951	2009	59
wild	6	<i>Forsythia suspensa</i>	beginning of flowering	48.5	1951	2009	59
wild	115	<i>Anemone nemorosa</i>	beginning of flowering	58.4	1951	2009	59
wild	176	<i>Quercus robur</i>	St. John's sprouts	28.9	1951	1990	40
wild	126	<i>Abies alba</i>	beginning of flowering	31.0	1951	1990	40
wild	228	<i>Crataegus laevigata</i>	first ripe fruits	18.6	1991	2009	19
wild	218	<i>Larix decidua</i>	needle fall	18.6	1991	2009	19
wild	222	<i>Cornus mas</i>	first ripe fruits	18.6	1991	2009	19
wild	213	<i>Artemisia vulgaris</i>	beginning of flowering	18.6	1991	2009	19
wild	217	<i>Larix decidua</i>	colouring of needles	18.6	1991	2009	19
agro	290	<i>Beta vulgaris</i>	emergence	30.5	1880	2009	130
agro	253	<i>Secale cereale</i>	beginning of flowering	60.7	1880	2009	130
agro	39	<i>Secale cereale</i>	full blossom	48.2	1880	2009	130
agro	302	<i>Zea mays</i>	beginning of yellow ripeness	24.3	1881	2009	129
agro	87	<i>Secale cereale</i>	beginning of full ripeness	30.3	1880	1990	111
agro	78	<i>Hordeum vulgare</i>	harvest	35.5	1880	1990	111
agro	83	<i>Hordeum vulgare</i>	harvest	38.0	1880	1990	111
agro	92	<i>Triticum aestivum</i>	beginning of full ripeness	30.2	1880	1990	111
agro	86	<i>Secale cereale</i>	harvest	57.8	1880	1990	111
agro	95	<i>Avena sativa</i>	beginning of yellow ripeness	46.0	1902	2009	108

agro	235	Avena sativa	beginning of milk ripeness	19.7	1902	2009	108
agro	91	Triticum aestivum	harvest	44.3	1890	1990	101
agro	37	Secale cereale	beginning of shooting	59.3	1921	2009	89
agro	144	Brassica napus, var. Napus	beginning of flowering	57.2	1922	2009	88
agro	181	Brassica napus, var. Napus	harvest	52.9	1922	2009	88
agro	98	Beta vulgaris var. crassa	harvest	61.2	1923	2009	87
agro	22	Avena sativa	emergence	60.7	1936	2009	74
agro	41	Triticum aestivum	beginning of heading	50.1	1936	2009	74
agro	150	Beta vulgaris var. crassa	tilling, sowing, drilling	46.4	1936	2009	74
agro	182	Brassica napus, var. Napus	tilling, sowing, drilling	46.7	1936	2009	74
agro	21	Avena sativa	tilling, sowing, drilling	61.9	1936	2009	74
agro	89	Secale cereale	emergence	64.2	1936	2009	74
agro	24	Avena sativa	beginning of tassel emergence	57.1	1936	2009	74
agro	38	Secale cereale	beginning of heading	57.4	1936	2009	74
agro	88	Secale cereale	tilling, sowing, drilling	59.3	1936	2009	74
agro	94	Triticum aestivum	emergence	55.2	1936	2009	74
agro	45	Beta vulgaris var. crassa	emergence	54.8	1936	2009	74
agro	75	Solanum tuberosum	beginning of flowering	41.3	1921	1991	71
agro	96	Avena sativa	harvest	43.4	1921	1990	70
agro	76	Solanum tuberosum	harvest	39.9	1921	1990	70
agro	301	Zea mays	beginning of wax-ripe stage	18.1	1945	2009	65
agro	303	Zea mays	harvest	19.4	1945	2009	65
agro	36	Hordeum vulgare	beginning of heading	49.3	1951	2009	59
agro	44	Beta vulgaris var. Altissima	closed stand	42.1	1951	2009	59
agro	99	Beta vulgaris var. Altissima	harvest	44.7	1951	2009	59
agro	183	Brassica napus, var. Napus	emergence	52.6	1951	2009	59
agro	85	Secale cereale	beginning of yellow ripeness	44.8	1951	2009	59
agro	141	Zea mays	emergence	44.0	1951	2009	59
agro	35	Hordeum vulgare	beginning of growth in height	48.7	1951	2009	59
agro	43	Beta vulgaris var. Altissima	emergence	43.8	1951	2009	59
agro	194	Triticum aestivum	beginning of harvest by combine	47.3	1951	2009	59
agro	40	Triticum aestivum	beginning of shooting	49.2	1951	2009	59
agro	140	Zea mays	tilling, sowing, drilling	44.4	1951	2009	59
agro	196	Zea mays	harvest	42.9	1951	2009	59
agro	42	Beta vulgaris var. Altissima	tilling, sowing, drilling	43.4	1951	2009	59
agro	77	Hordeum vulgare	beginning of yellow ripeness	44.4	1951	2009	59
agro	81	Hordeum vulgare	emergence	49.5	1951	2009	59
agro	241	Zea mays	beginning of yellow ripeness	20.6	1951	2009	59
agro	238	Zea mays	beginning of flowering	19.0	1951	2009	59
agro	80	Hordeum vulgare	tilling, sowing, drilling	49.6	1951	2009	59
agro	90	Triticum aestivum	beginning of yellow ripeness	45.0	1951	2009	59
agro	23	Avena sativa	beginning of growth in height	52.5	1951	2009	59
agro	93	Triticum aestivum	tilling, sowing, drilling	55.0	1951	2009	59

agro	142	Zea mays	beginning of tassel emergence	35.3	1951	2009	59
agro	237	Zea mays	beginning of shooting	21.0	1951	2009	59
agro	151	Beta vulgaris var. crassa	closed stand	43.6	1952	2009	58
agro	191	Hordeum vulgare	beginning of harvest by combine	49.6	1952	2009	58
agro	195	Avena sativa	beginning of harvest by combine	46.7	1952	2009	58
agro	26	Hordeum vulgare	emergence	40.0	1936	1991	56
agro	193	Secale cereale	beginning of harvest by combine	48.8	1954	2009	56
agro	30	Solanum tuberosum	emergence	32.1	1936	1990	55
agro	161	Trifolium pratense	1. cut for hay	31.0	1936	1990	55
agro	184	Trifolium pratense	2. cut for hay	29.5	1936	1990	55
agro	29	Solanum tuberosum	tilling, sowing, drilling	32.0	1936	1990	55
agro	180	Solanum tuberosum	harvest	32.0	1936	1990	55
agro	149	Solanum tuberosum	beginning of flowering	31.3	1936	1990	55
agro	185	Medicago sativa	2. cut for hay	28.3	1936	1990	55
agro	162	Medicago sativa	1. cut for hay	28.8	1936	1990	55
agro	199	Solanum lycopersicum	harvest	24.7	1951	1993	43
agro	34	Solanum tuberosum	closed stand	29.6	1951	1991	41
agro	25	Hordeum vulgare	tilling, sowing, drilling	34.3	1951	1991	41
agro	33	Solanum tuberosum	emergence	39.7	1951	1991	41
agro	28	Hordeum vulgare	beginning of heading	34.0	1951	1991	41
agro	32	Solanum tuberosum	tilling, sowing, drilling	39.8	1951	1991	41
agro	192	Hordeum vulgare	beginning of harvest by combine	31.6	1951	1991	41
agro	146	Solanum tuberosum	emergence	31.0	1951	1990	40
agro	137	Triticum aestivum	emergence	30.6	1951	1990	40
agro	153	Pisum sativa	emergence	30.0	1951	1990	40
agro	157	Phaseolus vulgaris	beginning of flowering	26.7	1951	1990	40
agro	197	Pisum sativa	harvest	30.0	1951	1990	40
agro	84	Hordeum vulgare	beginning of full ripeness	29.9	1951	1990	40
agro	145	Solanum tuberosum	tilling, sowing, drilling	30.9	1951	1990	40
agro	136	Triticum aestivum	tilling, sowing, drilling	31.2	1951	1990	40
agro	152	Pisum sativa	tilling, sowing, drilling	30.1	1951	1990	40
agro	156	Phaseolus vulgaris	emergence	30.3	1951	1990	40
agro	160	Brassica oleracea var. capitata	beginning of planting	36.4	1951	1990	40
agro	200	Brassica oleracea var. capitata	harvest	36.4	1951	1990	40
agro	148	Solanum tuberosum	beginning of flowering	30.4	1951	1990	40
agro	82	Hordeum vulgare	beginning of yellow ripeness	27.0	1951	1990	40
agro	139	Triticum aestivum	beginning of heading	30.9	1951	1990	40
agro	155	Phaseolus vulgaris	tilling, sowing, drilling	30.5	1951	1990	40
agro	159	Solanum lycopersicum	beginning of flowering	22.4	1951	1990	40
agro	188	Triticum aestivum	harvest	28.8	1951	1990	40
agro	143	Zea mays	full blossom	16.8	1951	1990	40
agro	147	Solanum tuberosum	closed stand	31.1	1951	1990	40
agro	179	Solanum tuberosum	harvest	30.8	1951	1990	40

agro	27	Hordeum vulgare	beginning of growth in height	31.4	1951	1990	40
agro	31	Solanum tuberosum	closed stand	29.7	1951	1990	40
agro	138	Triticum aestivum	beginning of growth in height	30.1	1951	1990	40
agro	154	Pisum sativa	beginning of flowering	29.3	1951	1990	40
agro	158	Solanum lycopersicum	beginning of planting	25.0	1951	1990	40
agro	187	Triticum aestivum	beginning of yellow ripeness	26.1	1951	1990	40
agro	198	Phaseolus vulgaris	harvest	30.3	1951	1990	40
agro	97	Avena sativa	beginning of full ripeness	29.4	1953	1990	38
agro	190	Triticum aestivum	beginning of harvest by combine	31.3	1954	1990	37
agro	189	Triticum aestivum	beginning of full ripeness	29.7	1954	1990	37
agro	79	Hordeum vulgare	beginning of full ripeness	29.5	1958	1990	33
agro	296	Zea mays	emergence	16.7	1985	2009	25
agro	295	Zea mays	tilling, sowing, drilling	16.8	1985	2009	25
agro	240	Zea mays	beginning of wax-ripe stage	18.1	1991	2009	19
agro	244	Helianthus annuus	emergence	16.9	1991	2009	19
agro	248	Helianthus annuus	harvest	16.9	1991	2009	19
agro	252	Brassica napus, var. Napus	beginning of rosette formation	18.6	1991	2009	19
agro	298	Zea mays	beginning of tassel emergence	16.2	1991	2009	19
agro	289	Beta vulgaris	tilling, sowing, drilling	11.3	1991	2009	19
agro	239	Zea mays	beginning of milk ripeness	18.2	1991	2009	19
agro	243	Helianthus annuus	tilling, sowing, drilling	17.1	1991	2009	19
agro	247	Helianthus annuus	beginning of flowering	17.0	1991	2009	19
agro	251	Brassica napus, var. Napus	beginning of full ripeness	18.7	1991	2009	19
agro	297	Zea mays	beginning of shooting	15.9	1991	2009	19
agro	246	Helianthus annuus	beginning of bud formation	16.8	1991	2009	19
agro	250	Brassica napus, var. Napus	beginning of bud formation	18.7	1991	2009	19
agro	300	Zea mays	beginning of milk ripeness	15.7	1991	2009	19
agro	292	Beta vulgaris	harvest	11.6	1991	2009	19
agro	245	Helianthus annuus	beginning unfolding of leaves	16.7	1991	2009	19
agro	249	Brassica napus, var. Napus	beginning of growth in height	18.6	1991	2009	19
agro	254	Triticum aestivum	beginning of milk ripeness	18.6	1991	2009	19
agro	299	Zea mays	beginning of flowering	16.1	1991	2009	19
agro	291	Beta vulgaris	closed stand	11.6	1991	2009	19
agro	236	Zea mays	FAO index	11.5	1986	2002	17
fruit	259	Malus domestica	beginning of sprouting	27.9	1880	2009	130
fruit	263	Malus domestica	leaf fall	20.6	1880	2009	130
fruit	63	Malus domestica	end of flowering	51.6	1880	2009	130
fruit	100	Ribes rubrum	fruit ripe for picking	76.6	1880	2009	130
fruit	164	Prunus cerasus	full flowering	51.3	1880	2009	130
fruit	107	Pyrus communis	fruit ripe for picking	55.1	1880	2009	130
fruit	257	Malus domestica	leaf fall	20.7	1880	2009	130
fruit	262	Malus domestica	end of flowering	23.0	1880	2009	130
fruit	304	Malus domestica	beginning of sprouting	24.3	1880	2009	130
fruit	53	Ribes uva-crispa	beginning of flowering	81.4	1880	2009	130
fruit	57	Prunus cerasus	end of flowering	50.9	1880	2009	130
fruit	62	Malus domestica	beginning of flowering	82.9	1880	2009	130
fruit	104	Prunus cerasus	fruit ripe for picking	57.3	1880	2009	130
fruit	167	Malus domestica	full flowering	51.1	1880	2009	130
fruit	256	Malus domestica	beginning of sprouting	19.1	1880	2009	130

fruit	261	Malus domestica	full flowering	21.3	1880	2009	130
fruit	52	Ribes uva-crispa	beginning unfolding of leaves	68.5	1880	2009	130
fruit	56	Prunus cerasus	beginning of flowering	71.8	1880	2009	130
fruit	61	Pyrus communis	end of flowering	50.6	1880	2009	130
fruit	111	Malus domestica	fruit ripe for picking	62.1	1880	2009	130
fruit	166	Pyrus communis	full flowering	51.1	1880	2009	130
fruit	109	Malus domestica	fruit ripe for picking	59.9	1880	2009	130
fruit	260	Malus domestica	beginning of flowering	38.8	1880	2009	130
fruit	268	Ribes uva-crispa	beginning of sprouting	21.1	1880	2009	130
fruit	51	Ribes rubrum	beginning of flowering	80.2	1880	2009	130
fruit	60	Pyrus communis	beginning of flowering	84.0	1880	2009	130
fruit	101	Ribes uva-crispa	fruit ripe for picking	63.6	1880	2009	130
fruit	108	Pyrus communis	fruit ripe for picking	57.4	1880	2009	130
fruit	305	Malus domestica	beginning of flowering	24.3	1881	2009	129
fruit	110	Malus domestica	fruit ripe for picking	38.5	1880	1992	113
fruit	58	Prunus domestica	beginning of flowering	38.0	1880	1991	112
fruit	50	Prunus persica	beginning of flowering	43.3	1880	1991	112
fruit	203	Rubus idaeus	first ripe fruits	42.3	1880	1990	111
fruit	169	Rubus idaeus	beginning of flowering	46.6	1880	1990	111
fruit	49	Prunus armeniaca	beginning of flowering	35.7	1880	1990	111
fruit	54	Prunus avium	beginning of flowering	70.0	1921	2009	89
fruit	103	Prunus avium	fruit ripe for picking	55.9	1922	2009	88
fruit	163	Prunus avium	full flowering	50.3	1936	2009	74
fruit	55	Prunus avium	end of flowering	50.2	1936	2009	74
fruit	307	Malus domestica	end of flowering	18.3	1945	2009	65
fruit	306	Malus domestica	full flowering	18.1	1945	2009	65
fruit	316	Pyrus communis	beginning of flowering	18.4	1951	2009	59
fruit	318	Pyrus communis	end of flowering	18.4	1951	2009	59
fruit	102	Prunus avium	fruit ripe for picking	55.5	1951	2009	59
fruit	317	Pyrus communis	full flowering	18.4	1951	2009	59
fruit	168	Fragaria	beginning of flowering	32.9	1936	1991	56
fruit	270	Prunus avium	leaf fall	18.5	1954	2009	56
fruit	202	Fragaria	fruit ripe for picking	32.7	1936	1991	56
fruit	106	Prunus domestica	fruit ripe for picking	37.0	1951	1991	41
fruit	105	Prunus domestica	fruit ripe for picking	37.0	1951	1991	41
fruit	204	Rubus	fruit ripe for picking	32.2	1951	1990	40
fruit	59	Prunus domestica	end of flowering	32.5	1951	1990	40
fruit	170	Rubus	beginning of flowering	32.3	1951	1990	40
fruit	165	Prunus domestica	full flowering	32.3	1951	1990	40
fruit	311	Malus domestica	beginning of flowering	15.6	1991	2009	19
fruit	315	Malus domestica	leaf fall	14.6	1991	2009	19
fruit	308	Malus domestica	fruit ripe for picking	16.2	1991	2009	19
fruit	314	Malus domestica	fruit ripe for picking	15.0	1991	2009	19
fruit	310	Malus domestica	beginning of sprouting	14.9	1991	2009	19
fruit	319	Pyrus communis	fruit ripe for picking	16.8	1991	2009	19
fruit	313	Malus domestica	end of flowering	15.5	1991	2009	19
fruit	324	Prunus avium	leaf fall	17.8	1991	2009	19
fruit	309	Malus domestica	leaf fall	16.0	1991	2009	19
fruit	321	Prunus avium	full flowering	18.1	1991	2009	19
fruit	312	Malus domestica	full flowering	15.5	1991	2009	19
fruit	322	Prunus avium	end of flowering	18.2	1991	2009	19
fruit	320	Prunus avium	beginning of flowering	18.2	1991	2009	19
vine	174	Vitis vinifera	end of flowering	38.8	1951	2009	59
vine	173	Vitis vinifera	full flowering	37.8	1951	2009	59
vine	207	Vitis vinifera	grape gathering	39.7	1951	2009	59
vine	211	Vitis vinifera	leaf fall	40.4	1951	2009	59
vine	172	Vitis vinifera	beginning of flowering	35.7	1951	2009	59
vine	171	Vitis vinifera	beginning of sprouting	31.3	1951	2009	59
vine	205	Vitis vinifera	grape gathering	37.4	1951	2009	59
vine	209	Vitis vinifera	leaf fall	37.5	1951	2009	59
vine	208	Vitis vinifera	grape gathering	28.9	1951	1990	40
vine	212	Vitis vinifera	leaf fall	25.4	1951	1990	40
vine	206	Vitis vinifera	grape gathering	30.5	1951	1990	40
vine	210	Vitis vinifera	leaf fall	30.1	1951	1990	40

vine	274	Vitis vinifera	beginning of ripening	18.1	1991	2009	19
vine	278	Vitis vinifera	beginning of sprouting	18.1	1991	2009	19
vine	282	Vitis vinifera	end of flowering	18.1	1991	2009	19
vine	273	Vitis vinifera	beginning unfolding of leaves	18.0	1991	2009	19
vine	277	Vitis vinifera	first bleeding of the vines	18.0	1991	2009	19
vine	281	Vitis vinifera	full flowering	18.1	1991	2009	19
vine	287	Vitis vinifera	altitude of vineyard (m)	18.1	1991	2009	19
vine	272	Vitis vinifera	first bleeding of the vines	18.1	1991	2009	19
vine	285	Vitis vinifera	altitude of vineyard (m)	18.0	1991	2009	19
vine	280	Vitis vinifera	beginning of flowering	18.2	1991	2009	19
vine	284	Vitis vinifera	colouring of leaves	18.1	1991	2009	19
vine	275	Vitis vinifera	colouring of leaves	17.9	1991	2009	19
vine	279	Vitis vinifera	beginning unfolding of leaves	18.2	1991	2009	19
vine	283	Vitis vinifera	beginning of ripening	18.1	1991	2009	19
vine	286	Vitis vinifera	method/exposition/inclinat	10.7	1991	2001	11

This table was retrieved from the database with the following query: “select plant_type, pid, plant_name_la, plant_name_en, phase_name_en, avg(c), min(min), max(max), max(max)-min(min)+1 l from (select phase_id pid, min(obs_year) min, max(obs_year) max, count(*) c from pheno_nr_ts group by naturraumgruppen_id, phase_id) as a, dwd_pheno_def b where a.pid=b.phase_id and plant_name_la!='NULL' group by pid order by plant_type, l desc;”