A Concise History of the Phenological Observations at the Royal Meteorological Institute of Belgium

Gaston R. Demarée[1] & Isabelle Chuine[2]

Abstract

This paper deals mainly with the history of phenological observations at the Royal Meteorological Institute of Belgium (RMIB) over the last 175 years. First, the setting of phenological observations in Europe in the 18th century is discussed. It is shown that Adolphe Quetelet was one of the 19th century trendsetters in these matters while Charles Morren can be credited for coining the word *"phenology"* in 1853. The possible interaction with the French *"Bureau Central Météorologique"* is highlighted not only for the similarity in their phenological instructions leaflets but also for the geographical and climatic neighbourhood of both countries. The 20th century's phenological observations and network at the RMIB are described into more detail. Finally, a section is dedicated to the today's use of phenological observations in the context of assessing long-term climatic variability and Global Change detection.

1. The European beginnings of phenology

In France, phenological studies go back as early as the 16th century with the pioneering observations of Gilles de Gouberville et du Mesnil-au-Val (1521-1578) but only published at the end of the 19th century (Tollemer, 1879). De Gouberville studied the differences in flowering phenology of apple tree varieties. It was René-Antoine Ferchault de Réaumur (1683-1757) who was the first one to suggest that temperature variations were probably one of the causes of the variations in phenology (Chuine, 2004). De Réaumur also defines and uses the notion of sum of degrees to compare the observations for different years (de Réaumur, 1738, p. 558). Quoting from de Réaumur: *"Cette année 1735 doit être mise au nombre des plus tardives; la récolte des bleds & celle des vins ont été faites au moins un mois plûtard que dans les années ordinaires. […] En 1734 les récoltes se sont faites d'assés bonne heure; j'ai été curieux de comparer la somme des degrés de chaleur au dessus de la congélation …pendant chacun de ces trois mois de 1734, avec la somme des degrés de chaleur qui ont agi pendant chacun de ces trois mois de 1735"*.

However, the first phenological observations ever realized in Europe are probably the grape harvest dates recorded since the Middle Ages, at least in France. The oldest and continuous series of grape harvest dates found so far concerns the Burgundy region and goes back to 1370 (Le Roy Ladurie, 1983; Chuine, 2004; Chuine *et al*., 2004).

The Swedish botanist and taxonomist Carl Linnaeus / Carl von Linné (1707-1778) described in his book "Philosophia Botanica" – its first edition in 1751 – the goals and methodology of phenological observations. He also founded a phenological network

[1] Gaston R. Demarée, Royal Meteorological Institute of Belgium, avenue Circulaire 3, B – 1780 Brussels, Belgium gaston.demaree@oma.be
[2] Isabelle Chuine, Equipe BIOFLUX, CEFE-CNRS 1919 route de Mende, F – 34293 Montpellier cedex 05, France isabelle.chuine@cefe.cnrs.fr

of 18 stations distributed over the territory of Sweden at that time. The network only existed from 1750 till 1752 (Ihne, 1884; Schnelle, 1955).

Robert Marsham is often considered as the founding father of modern phenological recording. He began recording his *"Indications of Spring"* back in 1736 on his family estate in Norfolk (Marsham, 1789). Pfister (1972) studied the carrying out of phenological observations in the framework of the Enlightenment by the Swiss natural scientist Johann Jakob Sprüngli (1717-1803).

Several observers of the network of the Societas Meteorologica Palatina at Mannheim contributed with phenological observations from the years 1781 till 1792 to the Ephemerides Societatis Meteorologicae Palatinae (1784-1795).

2. The earliest period in Belgium (before the 1830s)

Several natural scientists in Belgium made isolated phenological observations but it is, at the present stage of the historical research, not possible to speak about systematic phenological observations. These phenological observations are usually found in the extant meteorological manuscripts and are indicative of one of the leading motives for carrying out meteorological observations, namely agro-meteorology.

The main Belgian representative for agro-meteorology in 18th century was Baron Eugène-Joseph de Poederlé (1742-1815), a well-known arboriculturist, botanist, agronomist and meteorologist. De Poederlé corresponded with Buffon, Linneaus (Jr.), Daubenton, du Monceau and Cotte (Velle, 1985; Plisnier, 1994; Demarée *et al*., 2002). De Poederlé was an active member of *the "Société Royale d'Agriculture de Paris"*. His observations were made at his mansion house at Saintes, south of Brussels, in the summer while in the winter de Poederlé moved to Brussels. His register of meteorological observations covering the years 1785, 1786 and 1787 contain phenological observations on the page named *"Observations particulières"*.

First de Poederlé's weather description of the first months of 1785 is given in order to understand better his phenological observations: "At Brussels, February 1785: variable temperature, 6 rain-days and 12 snow-days; March 1785: very cold and dry temperature, 7 snow-days (24th, 25th and 31st abundantly); April 1785: cold and very dry temperature". At the end of March 1785, de Poederlé notes *"La campagne est comme en plein hiver, sans verdure ni végétation quelconques"*. In April, de Poederlé notes on the 9th: *"Depuis quelques jours on vend des bouquets de violettes dans nos rues";* on the 11th: *"Depuis quelques jours les abricotiers en espalier en ville commencent à fleurir"*; on the 13th: *"J'ai vu les premières hirondelles et le 14 les premiers grands Martinets"*; on the 15th: *"Les prairies commencent à verdoyer et les arbres les plus hâtifs à bourgeonner"*; on the 17th: *"Les Méléses [mélèzes], ordinairement très-hâtifs, ne commencent à bourgeonner. Le rossignol chanta à Saintes."*.

De Poederlé published his georgical-meteorological observations for the year IX of the French Republic in Lamarck's *"Annuaire météorologique pour l'An X"* leaving in

the monthly summaries a large part to the agricultural state of the month (de Poederlé, An X).

Other natural scientists like Théodore-Augustin Mann (1735-1809) and Guillaume-Lambert Godart (1721-1794) occasionally noted phenological observations in the margin of their meteorological manuscripts.

The charge of carrying out meteorological observations at the *Académie Royale et Impériale des Sciences et des Belles-Lettres de Bruxelles* for the *Societas Meteorologica Palatina* at Mannheim was given to Th.-A. Mann from 1784 onwards till the year 1792. The *observationes* of the years 1785, 1786, 1788-1792 contain phenological information under the heading *"Annotationes speciales in observationes bruxellenses"*. To give a few examples: *"Anni 1785, Aprilis, Dies 8: Violae florescebant; Dies 11: Mala armeniaca efflorescebant; Dies 13: Hirundines primo apparebant; Anni 1791, Martius, Die 31: Hirundus variae speciei primum visae, & Motacilla luscinia auditor; Die 15, Arbores & Prata ubique virescunt"*.

Pollard de Canivris, member of the *"Société de Médecine de Bruxelles"* and of the *"Comité central de vaccine"* during the French era, published in one of the leading Belgian newspapers in 1796 an agronomical calendar putting the observations of natural phenomena against thermometric observations at Louvain at 8 o'clock in the morning and at 4 o'clock in the afternoon (Pollard, 1796).

The first Chapter of the *"Mémoire statistique du Département de la Dyle"* (le Doulcet, de Pontécoulant, 1802) contains a section on *"Georgical observations"*. This section was most probably written by Pollard. It is noteworthy to see that the author refers to the work of Carl Linnaeus of 1753 [sic] and to the use of the sum of degrees for estimating the epoch of flowering. A calendar [in months] is given of the flowering; the thinning out of leaves of the principal threes and shrubs of the Dyle Departement.

Jean Kickx (Sr.) (1775-1831) published in his *Flora bruxellensis* (1812) phenological observations on the leaf unfolding and flowering for the year 1811.

J.C. Houzeau (1860) describes in his *Règles de Climatologie* published for the *Société pour l'émancipation intellectuelle* a thermometric calendar based on the temperature at 9 o'clock in the morning and not on the time of the year.

3. Adolphe Quetelet at the Royal Observatory of Brussels

In June 1826 King Guillaume I of the United Kingdom of the Netherlands founded the Royal Observatory of Brussels. Two years later, Adolphe Quetelet (1796-1874) was appointed astronomer but it took many more years – and a Belgian revolution - before the Brussels Observatory became finally operational on 1 January 1833 (Demarée, 1996; Demarée *et al.*, 2002).

Quetelet's early interest in periodical phenomena is demonstrated by the insertion of a table of average dates of flowering of plants in London and the arrival dates of the swallow (Hirundo rustica) in the publications of the Royal Observatory (Forster,

1837, 1838). The observations were carried out by Forster (Sr.) and Forster (Jr.) over a period of more than 50 years.

Quetelet started his own first observations on the grounds of the old Observatory in Saint-Josse-Ten-Noode in the years 1839 and 1840 (Quetelet, 1842). Soon the network created by Quetelet spread out over Belgium and over Europe totalising a network of approximately 80 stations for the period 1840 through the 1870s (Ihne, 1884; Schnelle, 1955; Lieth, 1974). A first overview of the observations of the periodical phenomena was published as chapter IV of the book *"Sur le Climat de la Belgique"* (Quetelet, 1849). A 15-pages leaflet, dated 25 April 1853, was printed by the Royal Academy of Sciences, of which Quetelet was the Permanent Secretary, containing the Instructions for the observation of periodical phenomena (Quetelet, 1853). Further observations of periodical phenomena were published in the Annals of the Observatory and/or in the Memoirs of the Belgian Academy (see e.g.: Quetelet, 1853 – for the year 1851).

Apparently, Quetelet's instructions form have inspired other meteorological services like the *"Bureau Central Météorologique"* of France where Eleuthère Mascart (1837-1908) issued in 1880 the form *"Observations sur les phénomènes de la végétation et sur les animaux"*. Furthermore, the published meteorological instructions of the *"Bureau Central Météorologique"* for the observers contained a brief analogous section (Angot, 1903, p. 111-115). Alfred Angot publishes the results of the observations in the memoirs of the *"Bureau Central Météorologique"* for the years, 1880 through 1890 (Angot, 1882/1892) with an overview of the observations for the decade 1881-1890 (Angot, 1894). Phenological observations in France started in 1880 and lasted up to 1944 in most meteorological stations. Only a few stations continued the observations up to the 1960s. Species observed in both countries differed quite a lot and only 17% of the species (22 species) observed in France were also observed in Belgium.

4. The coining of the word *"Phenology"*

Charles-François-Antoine Morren (1807-1858), a botanist at the University of Liège, contributed to the observations of periodical phenomena collected by Quetelet at the Royal Academy of Belgium. The title of these contributions usually contained the words *"phénomènes périodiques"*. However, in 1853, Charles Morren named his observations for the winter 1852-1853 *"phénologiques"*, coining the word "phenology" (Morren, 1853). Although Morren is often credited for the first use of the word "phenology", the exact reference to his paper is however extremely rare (Demarée, 1996). The word *"phenology"* is derived from the Greek words "phainestain" (= to appear) and "logos" (= study). Morren refers in his publication to the work of Clas Bjerkander (1735-1795), a Swedish botanist, who made research on the flora thermometer for the year 1777 (Bjerkander, 1778). Curiously enough, Quetelet at Brussels and Mascart at Paris continued to use the term *"periodical phenomena"*.

5. The phenological observations at the Royal Meteorological Institute at Uccle (1896-1983)

In the 1870s meteorology and climatology underwent a worldwide radical change. Being the domain of natural scientists in the 18th century, and of natural scientists and physicists in the 19th century under the umbrella of academies, universities or societies, the subject became a governmental matter within specific ministries by the creation of National Meteorological Services (NMSs).

Following the resolutions of the Vienna meeting in September 1873 of the International Meteorological Organisation (IMO) – the forerunner of the present World Meteorological Organisation (WMO) – the procedures of climatological observations were standardized. In Belgium, the first meteorological forecast bulletin was issued on September 1st, 1876, and open thermometric screens were introduced in 1878. Albert Lancaster (1849-1908) built a dense climatological network between 1876 and 1879. Finally, in November 1890, the Observatory was moved from the site at the Porte de Schaerbeek where it gradually had become enclosed by the expanding city to the new rural site on the Uccle plateau; 6 km SSE as the crow flies from the old site. In 1913, the *"Service météorologique"* at the Observatory became an autonomous institution with the name *"Institut Royal Météorologique de Belgique (IRM)"*.

Meuris and Vincent (1881) described the periodical phenomena of migrating birds in Belgium. In 1896, Jean Vincent (1851-1932) started to carry out phenological observations at Uccle. The plants and shrubs form a large double circle delimitating the climatological parc (see Figure) located on the top of a hill, about 100 m above sea level and with silt soil conditions. Emile Vanderlinden (1870-1950) published a first result of the phenological observations with respect to the climatic variations of 39 shrubs for the reference period 1896-1909 (Vanderlinden, 1912). Vanderlinden (1920, 1922) published a more comprehensive report on herbaceous as well as on woody species covering the reference period 1896/1906 through 1920.

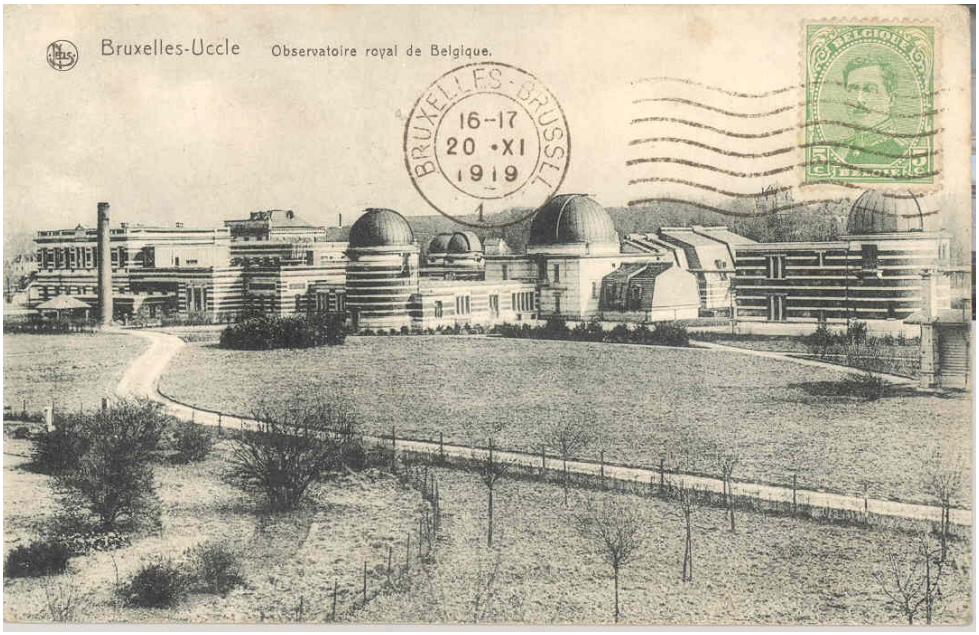

Fig. 1. Postcard showing the Royal Observatory of Belgium in 1919. In the left lower corner, a part of the circular enclosure around the climatological garden and of the two circular rows of the herbaceous and woody plants of the phenological garden can be seen.

In the Interbellum, the phenological observations were continued but no data of individual years could be traced at present. However, Emile Lardinois (°1899) produced a table with average annual values for the first flowering. After World War II, Simon De Backer (1900-1985), André Vandenplas (1913-1991) and Paul Lelouchier (1932-1992), assisted by Emile Lardinois until 1963, René Lenaerts (1914-1979) until 1979, Maria Borms (°1925) and Luc Trullemans took up the phenological observations within the sections Agro- & Bioclimatology and General Climatology. De Backer (1947) started with some experiments in the observation of the Galanthus nivalis. The detailed annual phenological observations were published in *"Ciel et Terre"* at the Royal Observatory of Belgium and in the *"Bulletin mensuel climatologique"* of the Royal Meteorological Institute of Belgium.

However, after the retirement of Raymond Sneyers (1918-2006) in April 1983, a *"Rationalisation of the climatological observations"* suppressed the phenological observations so that 1983 is the last year of the nearly centennial phenological time-series at the Royal Meteorological Institute of Belgium. Herewith, Belgian climatologists were deprived of a working tool of a robust indicator of assessing the recent climatic warming (Hambuckers, 2004).

The authors of this paper have encoded and checked the Uccle phenological data and the data set will be made available in the framework of the OPHELIE and COST-725 projects.

6. The Belgian phenological network of the RMIB (1943-1977)

During the Second World War, the IRM was forced to work under *"Deutsche Leitung"* and it was strictly forbidden to engage in synoptic observations and weather forecasting activities as that could influence the operations on the war fronts. It is possible that this situation as well as the scientific interest of the initiators lead to the founding of a Belgian phenological network. On 11 March 1943, a circular letter was signed by A. Van den Broeck, Director of the RMIB, on the organisation of the phenological network; another circular letter concerning the year 1944 was dated on 15.I.1944. The phenological archives contain about one thousand addresses of potentially interested people, among them farmers, teachers, agricultural schools, naturalists, apiculturists, etc.

The questionnaire consisted of 4 double-pages sheets: Group A perennial plants; Group B "plantes de grande culture" (cereals, potatoes, beets, flax, lupin, rape/colza, tobacco, hop and faba beans); Group C fruit trees and Group D damages to harvests (meteorological accidents, illnesses, insects). The archives of the network contain responses of near to 50 observers over the reference period 1943-1977; among them Sister Marie-Paul at Bastogne (Group A), Questiaux at Dinant (Group A), Detry Jacques at Juprelle-Liège (Groups A, B, C and D) and Glibert Louis at Ohain,

Gembloux and Blanmont-Chastre for the reference period (1948-1976). It is not known what were the exact reasons behind the cessation of the network activities but in the 1970s a mere 4 observers were active.

7. Today's use of the phenological observations

These phenological observations are used today in different research fields among which, past climate reconstruction, climate change impact assessment and management. Indeed long-term phenological time-series are excellent indicators of climatic variability on decadal and centennial time scale while more recent series are able of assessing statistically significant signals in climate change over the last half-century.

Grape harvest dates have, for example, been used to reconstruct temperature anomalies of Burgundy over the very long-term period 1370-2003 (Chuine, 2004; Chuine *et al*., 2004). Such reconstructions are based on process-based phenological models calibrated with phenological data of the Pinot Noir grape.

Yan *et al*. (1997) used a linear regression model April to September temperature – vintage dates at Dijon (AD 1366-1837) to calibrate temperature anomalies in the extended and augmented Alexandre's data set of historical records on temperature (and precipitation) ranging from AD 708 till 1426 (Alexandre, 1987).

On the other hand, numerous studies concluded on the basis of phenological observations of the second half of the 20th century to an earlier onset of spring, and, to a lesser degree, a later onset of autumn, extending its growing season (Menzel and Fabian, 1999). In this way, phenology proved it usefulness to the Global Change Community (Menzel, 2002). Based upon a data set of more than 125,000 observations of plant and animal species in 21 European countries Menzel *et al*. (2006) were able to prove that 78% of all leafing, flowering and fruiting stage records were significantly advanced whereas the signal of leaf colouring / fall is ambiguous.

Scheifinger *et al*. (2006) studying 48 selected phenological phases in Austria for the reference period 1951-2005, noted negative trend dates indicative for earlier occurrences for most of the phases – many of them significant. However, when comparing the trends of the 2 different periods: trend (1951-2005) – trend (1951-2000), the shift in trend is either positive or negative, which means that, in general, trends between 2001 and 2005 towards still earlier observing dates could not be observed.

Acknowledgements

This paper is being realized within the framework of the COST-725 action *"Establishing a European Phenological Data Platform for Climatological Applications"*. The authors are grateful for the financial support provided within the COST action terms. They acknowledge the help, courtesy and guidance by Pavol Nejedlik, COST-725 science officer, and Elisabeth Koch, chair of the COST-725 Management Committee.

References

Alexandre, P. (1987) Le climat en Europe au Moyen Age. Contribution à l'histoire des variations climatiques de 1000 à 1425, d'après les sources narratives de l'Europe occidentale. Editions de l'Ecole des Hautes Etudes en Sciences Sociales. Paris, 827 p.

Angot, A. (1882/1892) Etude sur la marche des phénomènes de vegetation et la migration des oiseaux en France, pendant les dix années 1880 …1890. Annales du Bureau Central Météorologique, Mémoires.

Angot, A. (1894) Résumé des etudes sur la marche des phénomènes de vegetation et la migration des oiseaux en France pendant les dix années 1881-1890. Annales du Bureau Central Météorologique, Année 1892. Mémoires, B.159-B.210.

Angot, A. (1903) Observations sur les phénomènes périodiques de la végétation et sur les animaux. In: Instructions météorologiques. Quatrième edition, entièrement refondue. Paris, Gauthier-Villars, p. 111-115.

Bjerkander, C. (1778) Försök til et thermometrum florae för år 1777. K. Svenska vetenskapsakademiens handlingar. Vol. 39, Stockholm.

Chuine, I. (2004) La place des données de phénologie dans l'étude des changements climatiques en France. Lettre pigb-pmrc France n° 16 – Changement global, p. 65-66.

Chuine, I., Yiou, P., Viovy, N., Seguin, P., Daux, V. & Le Roy Ladurie, E. (2004) Grape ripening as a past climate indicator. Summer temperature variations are reconstructed from harvest dates since 1370. Nature, vol. 432, p. 289-290.

De Backer, S.M. (1947) Influence de la Température sur le Perce-Neige (Galanthus Nivalis L.). Observations pendant l'hiver 1946-1947. IRM, Miscellanées, Fasc. XXVII, 16 p.

[le Doulcet , comte de Pontécoulant] (An X [1802]) Extrait du Mémoire statistique du Département de la Dyle, Adressé par le Préfet au Ministre de l'Intérieur, en l'An 10, A Bruxelles, De l'Imprimerie de Weissenbruch, 212 p., 3 tableaux.

Demarée, G.R. (1996) Adolphe Quetelet (1796-1874): Précurseur du réseau belge d'observations climatologiques. Bulletin Astronomique. Volume XI, No. 1, p. 41-52.

Demarée, G.R., Lachaert, P.-J., Verhoeve, T. & Thoen, E. (2002) The long-term daily central Belgium Temperature (CBT) Time-Series (1767-1998) and early instrumental meteorological Observations in Belgium. Climatic Change, 53, p. 269-293.

Ephemerides Societatis Meteorologicae Palatinae (1784-1795) Manheimii.

[Forster] (1837/1838) Calendrier des moyens temps de la floraison des plantes; Notice sur les hirondelles et les autres oiseaux de passage; Table de la première apparition de l'Hirondelle de cheminée …; Table des temps moyens de la première apparition des

oiseaux voyageurs à Londres … Annuaire de l'Observatoire de Bruxelles, pour l'an 1838, Bruxelles, Hayez, p. 214-240; Correspondance mathématique et Physique, Tome X, Bruxelles, Société belge de Librairie, p. 419-440.

Godart; Guillaume-Lambert: Registre des observations météorologiques et des visites médicales. 1er janvier 1767 - 31st décembre 1790, 1er janvier 1791 - 8 février 1794, 2 tomes. Manuscript Abbé Hubert de Thier, Brussels, Belgium.

Hambuckers, A. (2004) Biodiversité. Impacts des changements climatiques en Belgique. Université Catholique de Louvain - Greenpeace, p. 21-25, références, p. 41.

Houzeau, J.C. (1860) Règles de climatologie ou Exposé sommaire des notions que la science possède sur le cours des saisons et sur les variations du temps. Société pour l'émancipation intellectuelle, A. Jamar, Éditeur, 104 p

Ihne, E. (1884) Geschichte der pflanzenphänologischen Beobachtungen in Europa nebst Verzeichniss der Schriften, in welchen dieselben niedergelegt sind. Beiträge zur Phänologie, I. Giessen, J. Ricker'sche Buchhandlung, 138 p.

Kickx, J. (1812) Flora Bruxellensis, exhibens characters generum et specierum plantarum circum Bruxellas crescentium, … Bruxellis.

Le Roy Ladurie, E. (1983) Histoire du climat depuis l'an mil. Paris, Flammarion, 2 vol., 287 + 254 p.

Lieth, H. (1974) Phenology and Seasonality Modeling. Berlin – Heidelberg – New York, Springer-Verlag.

Mann, Théodore-Augustin: Observations météorologiques faites à Nieuport. Depuis le 1. Octobre 1775 jusqu'à la Fin d'Avril 1777; par Augustin-Théodore Mann, Membre Ordinaire de l'Académie Impériale et Royale des Sciences et Belles-Lettres de Bruxelles. Fonds van Swinden *"Meteorologie en Noorderlicht"*, Koninklijke Bibliotheek, The Hague, The Netherlands.

Marsham, R. (1789) Indications of Spring, observed by Robert Marsham, Esquire, F.R.S. of Stratton in Norfolk. Philosophical transactions of the Royal Society of London, Vol. LXXIX. For the Year 1789, Part II, p. 154-156.

Menzel, A. & Fabian, P. (1999) Growing season extended in Europe. Nature, Vol. 397, p. 659.

Menzel, A. (2002) Phenology, its importance to the Global Change Community. Climatic Change, 54, p. 379-385.

Menzel, A., Sparks, T.H., Estrella, N., Koch, E., … (2006) European phenological response to climate change matches the warning pattern. Global Change Biology, 12, 1969-1976, doi: 10.1111/j.1365-2486.2006.01193.x

Meuris, A. et Vincent, J. (1881) Phénomènes périodiques naturels. Ciel et Terre, Première Année, p. 171-176, 205-210 et 231-236.

Morren, Ch. (1853) Souvenirs phénologiques de l'hiver 1852-1853. Bulletin de l'Académie royale des Sciences, des Lettres et des Beaux-Arts de Belgique. Tome XX, 1e partie, p. 160-186.

"Observations sur les phénomènes de la végétation et sur les animaux" (1880) Météorologie Nationale E.C.M.-T/Clim N° 78E, Paris.

de Poederlé, le Baron. Régître d'Observations météorologiques commencé le 1 janvier 1785. fini avec l'année 1787. Manuscript 15.503, Royal Library Albertina, Brussels, Belgium.

de Poederlé (An X) EXTRAIT des observations géorgicó-météorologiques faites à Bruxelles ou aux environs, pendant l'an 9 de l'ère française, par le citoyen Poederlé, Etc. et envoyées au bureau de la statistique de France. Annuaire météorologique, pour l'an X de l'ère de la République française; à l'usage des Agriculteurs, des Médecins, des Marins, &c. par J.B. Lamarck, N° 3. A Paris, Chez l'Auteur, Chez Maillard, p. 86-101.

Pfister, C. (1972) Phänologische Beobachtungen in der Schweiz der Aufklärung. Informationen Beiträge Klimaforschung, 8, p. 15-30.

Plisnier, R. (1994) Le voyage en France du Baron de Poederlé (1769), *Mémoires et Publications de la Société des Sciences, des Arts et des Lettres du Hainaut* 97, 27-49.

[Pollard] (1796) Calendrier agronome. Esprit des Journaux. 25e année, t. II, mars et avril 1796, p. 288.

[Quetelet, A.] (1842) Calendrier pour la floraison, d'après les observations faites en 1839, dans le jardin de l'Observatoire. Calendrier pour la floraison, d'après les observations faites en 1840, dans le jardin de l'Observatoire. Annales de l'Observatoire Royal de Bruxelles, Tome II, Bruxelles, Hayez, p. 203-204; p. 292-294.

Quetelet, A. (1849) Sur le Climat de la Belgique. Tome Premier, Première Partie, Chapitre IV Des phénomènes périodiques des plantes. Hayez, Bruxelles, p. 1-187, 2 Planches.

[Quetelet, A.] (1853) Observations des Phénomènes périodiques [pour l'année 1851]. I. Météorologie et physique du globe, II. Observations botaniques, III. Observations zoologiques. Mémoires de l'Académie Royale des Sciences, des Lettres et des Beaux-Arts, Tome XXVII, p. 3-66.

Quetelet, A. (1853) Instructions pour l'observation des phénomènes périodiques. Académie royale des Sciences, des Lettres et des Beaux-Arts de Belgique. Bruxelles, 15 p.

de Réaumur (1738) Observations du thermomètre, Faites à Paris pendant l'année M.DCCXXXV. Comparées avec celles qui ont été faites sous la Ligne; à l'Isle de France, à Alger, & en quelques-unes de nos Isles de l'Amérique. Histoire de

l'Académie Royale des Sciences. Année M.DCCXXXV. A Paris, de l'Imprimerie Royale, p. 545-576.

Scheifinger, H., Koch, E., Cate, P. & Matulla, C. (2006) CLIMPHEN: a comprehensive analysis of Austria's plant and insect phenological observations 1951-2005. 1 p.

Schnelle, F. (1955) Pflanzen-Phänologie. Leipzig, Akademische Verlagsgesellschaft Geest & Portig, 299 p.

Tollemer, A. (1879) Journal manuscrit d'un sire de Gouberville et du Mesnil-au-Val, gentilhomme campagnard, au Cotentin, de 1553 à 1562. Rennes, typ. de Oberthur et fils, 2e éd., 846 p.

Vanderlinden, E. (1910) Étude sur les phénomènes périodiques de la végétation dans leurs rapports avec les variations climatiques. Receuil de l'Institut botanique Léo Errera, T. VIII, Bruxelles, Hayez, p. 247-296, Planche.

Vanderlinden, E. (1912) Sur les anomalies climatiques et phénologiques du dernier hiver [1911-1912]. Extrait de la Revue des Questions scientifiques, avril 1912, 11 p.

Vanderlinden, E. (1920) Botanique. - Quelques résultats d'observations phénologiques sur des végétaux. Extrait des Bulletins de la Classe des sciences, Académie royale de Belgique, no. 12, p. 577-585.

Vanderlinden, E. (1922) Observations phénologiques sur les végetaux. Extrait du Recueil de l'Institut Léo Errera, Tome X. Bruxelles, Imprimerie médicale et scientifique, 14 p., IV Tableaux et 15 Planches.

Velle, K. (1985) Baron de Poederlé (1742-1813) en de meteorologie en geneeskunde in de late 18de eeuw', *Oostvlaamse Zanten - Tweemaandelijks Algemeen Tijdschrift voor* Volkskunde 60, 1, p. 49-52.

Yan, Z., Alexandre, P., Demarée, G. (1997) Narrative warm/cold variations in Continental Western Europe, AD 708 to 1426. Science in China (Series D), Vol. 40, No. 5, p. 509-517.