Final Scientific Report of COST 725

Establishing a European dataplatform for climatological applications

COST – European **CO**operation in the field of **S**cientific and **T**echnical Research – is the oldest and widest intergovernmental European network for cooperation in research. Established by the Ministerial Conference in November 1971, COST is presently used by the scientific communities of 35 European countries to cooperate in common research projects supported by national funds.
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European Cooperation in the field of Scientific and Technical Research

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Directory

1. Introduction

Phenology is the study of the timing of recurring biological events in the animal and plant world. Leaf unfolding and flowering of plants in spring, fruit ripening, colour changing and leaf fall in autumn, as well as the arrival and departure of migrating birds and the timing of animal breeding are all examples. In the 19th century, phonological recording was a traditional activity but interest in observation declined in the early 20th century. However, in recent decades phenology has rapidly become an important tool for climate change impact studies and COST725 contributed significantly to this renewed interest. In the 4th assessment report of IPCC the results of phenological research especially in Europe play a major role in assessing the observed changes in natural and managed systems. The impacts of climate change on plants is easily observed which is also one of the reasons why phenology has gained much public interest and it is common to find phenological articles reported in the media.

Europe is fortunate to have a long tradition in phenological networking: the history of collecting phenological data and using them in climatology began in 1751 when Carl von Linné outlined in his work Philosophia Botanica methods for compiling annual plant calendars of leaf opening, flowering, fruiting and leaf fall together with climatological observations “so as to show how areas differ”. The Societas Meteorologicae Palatinae at Mannheim well known for its first European wide meteorological network also established a phenological network which was active from 1781 to 1792.

Recently phenological observations have been carried out routinely for more than 50 years in most European countries by different governmental and nongovernmental organisations. However, data collection is not standardised and different observation guidelines are followed. In addition, the data are stored in different locations and in different formats which has been a major obstacle to implement pan European research.

In 2004 the five year COST action 725 started with the main objective to establish a European reference data set of phenological observations that could be used for climatological purposes, especially climate monitoring, and detection of change.

Secondary objectives lay in the standardisation of techniques for:

- Defining of species and phases, that should be observed in a standard manner
- Developing recommendations for monitoring and collection procedures (methodologies, sampling density, frequency, etc.)
- Selection criteria of data for further consideration
- Quality control of observations
- Commonly used formats of archiving and distribution of data
- Mapping techniques of phenological information and other application methods
- Increasing the knowledge concerning relations between climate and phenological events

2. Scientific Report of COST725

At its first meeting in Brussels in April 2004, three working groups (WG) were established at the management committee meeting as follows

WG1: Inventory of data and metadata

WG2: Guidelines for data selection, observations and archiving

WG3: Applications with phenological data

2.1. WG1 Inventory of data and metadata

Jiri Nekovar from the National Hydro Meteorological Institute of Czech Republic and his vice Frans Emil Wielgolaski from the University of Oslo chaired this working roup.

The first step of WG1 was the evaluation of the present status of phenological networks in the participating member states. Jiri Nekovar developed a questionnaire that was sent out in May 2004 to the COST725 participants to assess the observation sites, the plants and phenological phases under observation (inventory of data) and last but not least the metadata of the observation sites as geographical latitude and longitude, altitude, observation period, reference meteorological station, observation guidelines, and if available other information on e.g. soil characteristics (figure 1).

COST action 725 - Inventory of Data and Metadata				*METADATA TABLE*		Date:	18.08.2005
					Contact person:		
Country:		Bulgaria				Observation	
Nr	Station's name	Region	longitude	latitude	elevation	from 1951	till now
1301	Knezha	Nord-West	2405E	4330N	120		
1. Geographical description of the station							
Landscape		hilly	mountains	*plain*	other types		
Distance to the sea		*320 km*					
Position		hill / top	slope	valley/basin	*plain*		
Extension surrounding		town	fringe of a town	agricult.surfaces	meadows	forest	
Close surroundings		buildings	waters	trees	*open surface*		
Inclination		*0º - 5º*	5º - 10º	10º - 15º	15º - 20º	>20º	
Exposition		south	north	west	east	*sw*	
Soil type		sand	loamy sand	sandy loam	*loam*	loess	clay
Field capacity		0 - 100 cm; if known		xxx			
2.1. Situation with respect to the large-scale landscape					*plain-lowland*		
2.2. Situation with respect to the relief of the landscape (determining the climate)					*lowland*		
2.3. Soil condition (kind of soil, type of soil)					*Eutric Planosols*		
2.4. Water condition					*damp climatic area*		
3.1. Photographs (showing the caracter of the station and the surrounding next to it;if available air photo)							yes /no
3.2. Map of the region (showing the relief of the landscape as for as possible scale 1:100 000)							yes/ no

Figure 1: Questionnaire on "Inventory of Data and Metadata"

The outcome of the questionnaires was evaluated at a WG1 expert meeting in Prague in fall 2004: from more than 500 different plants and phases a list of plants and phenological phases for a common European phenological data platform was developed and presented at the 3rd MCM in Vienna in April 2005. At the following combined workshop of WGl and WG2 the plants/species/phenological events were selected for the COST725 database.

In 2008 Jiri Nekovar (chief editor) published the book "The history and present status of plant phenology in Europe" with contributions from all COST725 members plus Croatia, Bosnia and Herzegovina, Montenegro and the International Phenological Gardens. Though there is a long history of phenological information in the former USSR and recordings in Russia, Belarus and the Ukraine are ongoing it was not possible to include information on all European countries due time constraints.

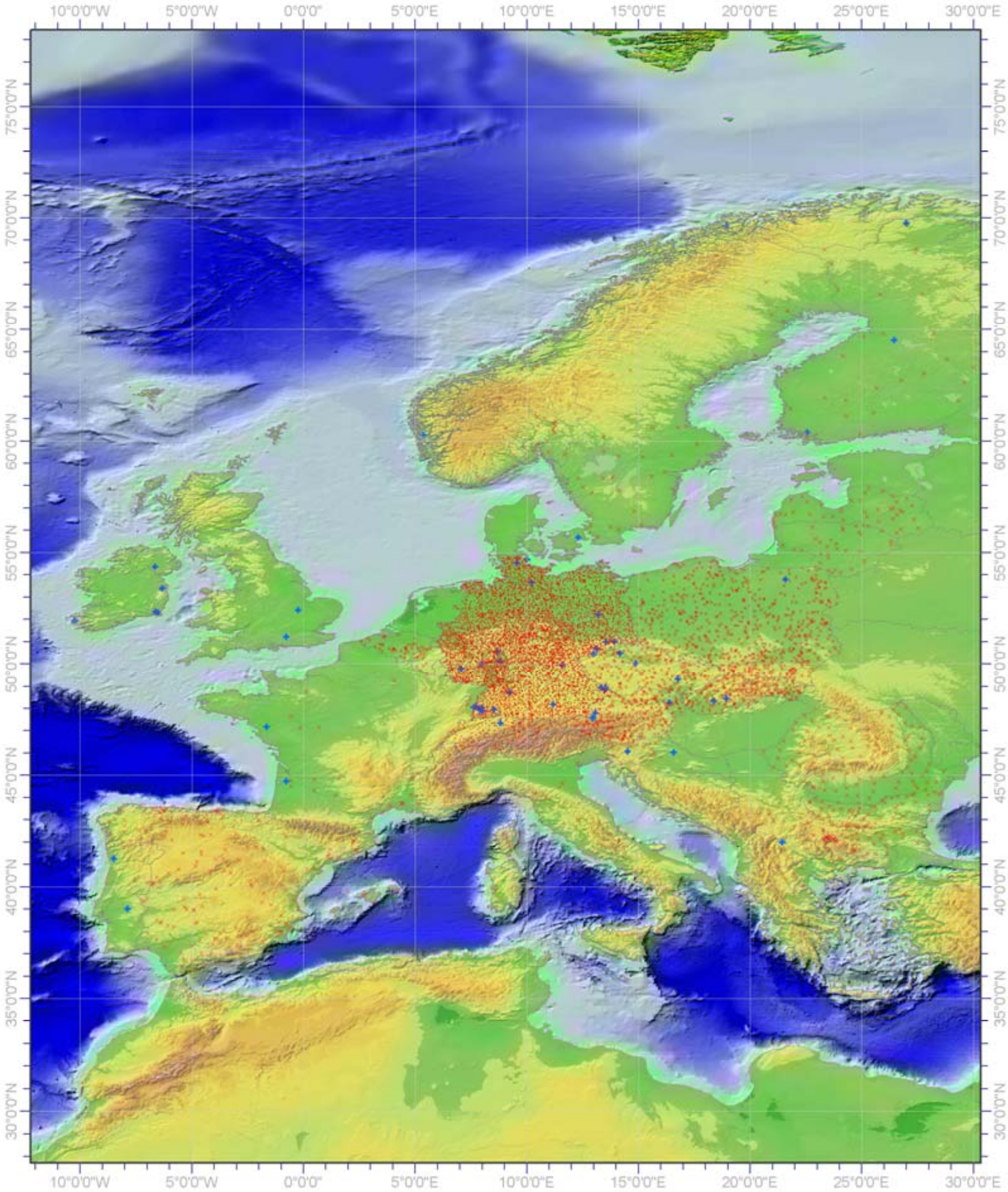


Figure 2: Map showing European phenological stations (output of the questionnaire)

Like meteorological observations, long-term data sets series of phenological plant observations can reveal trends reflecting variations in climate through decades and even centuries. However, there have been, and still are, strongly differing opinions on the importance on phenological information in different European countries. In some countries interest declined after the Second World War whilst in Central and Eastern Europe this period saw an intensive activity in phenology. In more recent time Climate Change has, of course, become especially important: it has been demonstrated that a plant phenology network could give clear, visible and understandable indications of such changes. It is now widely accepted that phenology can provide an early warning system of climate change impacts. This has given new emphases to existing networks and has allowed the re-establishment of others using new technology for example in the Netherlands. Climate Change will also be a major incentive in the detection and computerization of historical phenological records.

Two workshops (Huntingdon, El Escorial) and two STSM were dedicated to the finalization of this publication.

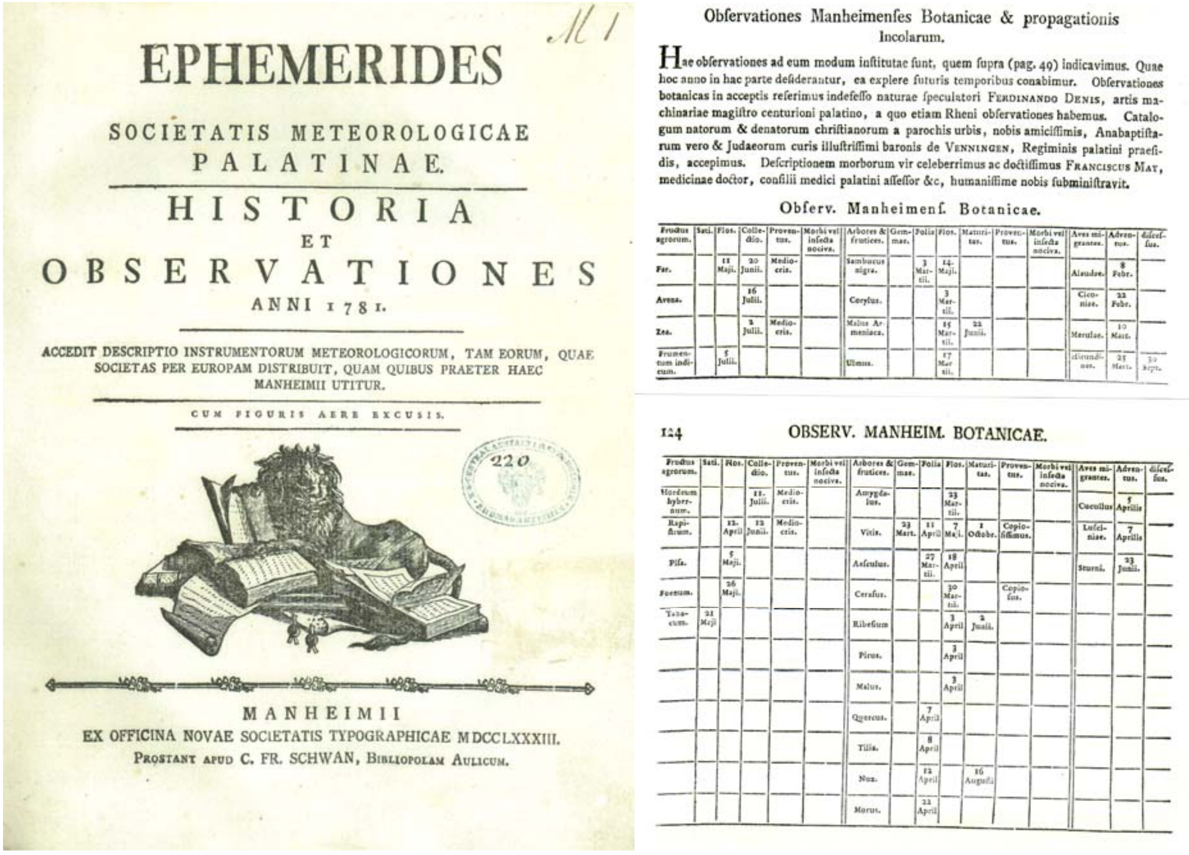


Figure 3: Front page of the first edition EPHEMERIDES of the SOCIETATIS METEOROLOGICAE PALATINAE, published in 1783 (left) containing phenological observations from Mannheim (right) from 1781

In 2008 WG1 organized a workshop on: “Benefit of old phenodata series-evaluation & declaring ability” with 22 oral presentations. The topics covered more than 700 years (GARCIA DE CORTAZAR-ATAURI, I. CHUINE, V. DAUX, E. GARNIER, N. VIOVY, B. SEGUIN, G. DEMARÉE, P. YIOU: Seven centuries of grape harvesting in France. What does it tell us about climate dynamics?) from across Europe (from Ø. NORDLI: Grain harvest in three Norwegian regions and in the mountain valleys and E. KUBIN, J. TERHIVUO, J. KARHU: Phenological observation since the days of Linné up to 2008 in Finland to E. TSIROS, C. DOMENIKIOTIS and N.R. DALEZIOS: Assessment of cotton phenological stages using agroclimatic indices – in Greece). Grape harvest dates was of particular interest to the phenologists – 7 contributions revealed the long history of vine growing in Europe. Grape harvest days and other phenological data can be used as climate proxies as they strongly depend on temperature in the foregoing months. Thus by setting up correlations between phenological data and temperature gained from observations during the instrumental period it is possible to extend the temperature time series into the pre-instrumental era.

The Italian Journal of Agrometeorology published a special issue on the proceedings of this workshop in 2009.

2.2. WG2 Guidelines for data selection, observations and archiving

Working Group 2 was chaired by Wolfgang Lipa (ZAMG) and Kirsten Zimmermann (DWD), assisted by Susanne Zach Hermann (ZAMG).

The main goal of WG2 was to:

- establish and maintain a European phenological database
- determine a list of the most common plants and phases in cooperation with WG 1

- apply a uniform coding system for phenological phases – the BBCH scale

- collect and apply - national experience relating to quality control of data to the common database
- build a flagging system for identification of possible errors and outliers,
- make recommendations for monitoring and collecting procedures

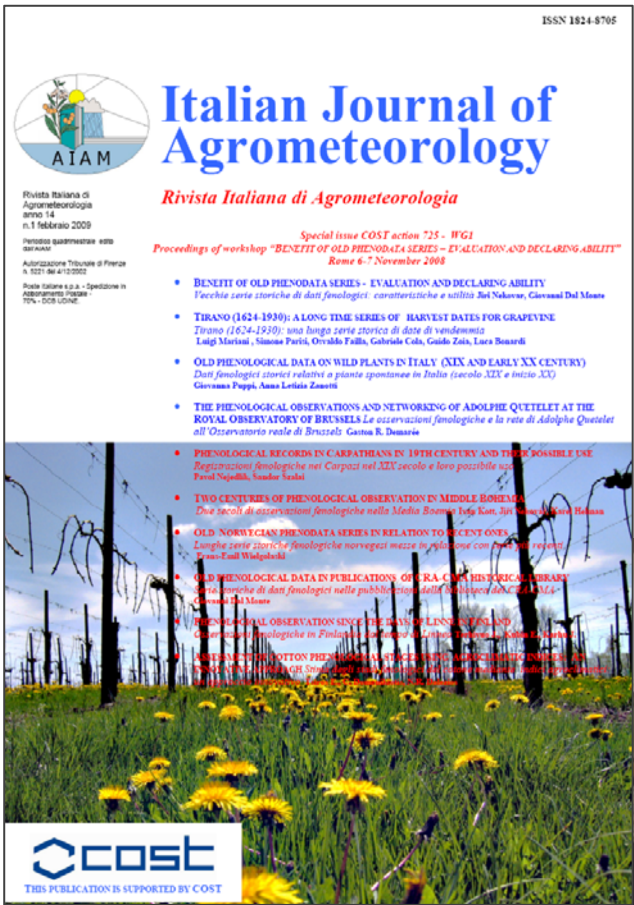


Figure 4: Front cover (above) of the proceedings of the WG 1 workshop held in Rome November 2008 (right)

Recommendations for monitoring and collecting procedures, application of BBCH code

The MC agreed at the meeting in Budapest to apply the BBCH scale (Meier, 1997)[1] to all national phenological observations across Europe. The first attempts to standardise the different national phenological event descriptions were made by Bruns and Vliet (2003)[2] who was an invited expert of COST725 and presented the BBCH scale at the MCM in Budapest, 2004.

COST725 members and invited experts (Koch et al., 2008) developed "Guidelines for plant phenological observations", which could be finalized during a STSM of F.-M. Chmielewski at the host institute ZAMG in Vienna. After a reviewing procedure WCMP /WCP / WMO accepted these guidelines as a standard for phenological observations and published them at

http://www.omm.urv.cat/documentation.html

The BBCH scale differentiates the plant development into 10 principal growth stages that are subdivided into secondary stages from 0 to 9 (figure 5).

[1] Meier, U., 1997: Growth Stages of Mono- and Dicotyledonous Plants. Blackwell Wissenschaftsverlag
[2] Bruns, E., A.J.H. van Vliet, 2003: Standardisation of phenological monitoring in Europe, Wageningen University and DWD

Principal Growth Stages	Description
0	Germination / sprouting / bud development
1	Leaf development (main shoot)
2	Formation of side shoots / tillering
3	Stem elongation or rosette growth / shoot development (mainshoot)
4	Development of harvestable vegetative plant parts or vegetatively propagated organs / booting (main shoot)
5	Inflorescence emergence (main shoot) / Heading
6	Flowering (main shoot)
7	Development of fruit
8	Ripening or maturity of fruit and seeds
9	Senescence beginning of dormancy

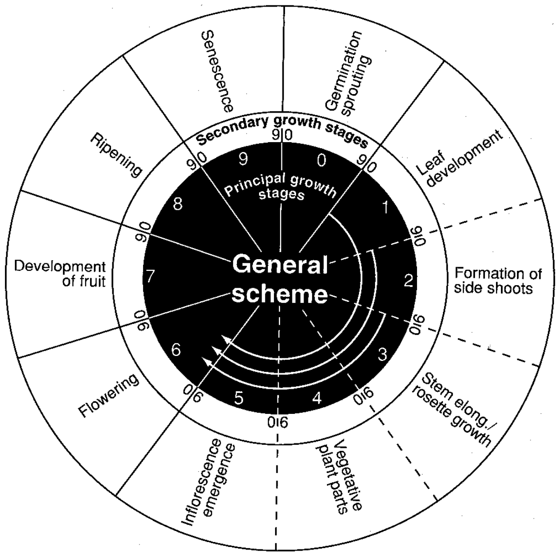


Figure 5: Principal and secondary growth stages of the BBCH code (source Growth stages of plants, Meier, 1997)

National experience relating to quality control of data to the common database

A questionnaire on data quality checking routines was developed, sent out and evaluated by Ana Žust and Andreja Sušnik (EARS) in 2006.

To sum up the outcomes of the questionnaire most of the data belonged to governmental, research and educational institutions, quality checks were performed regularly, but no standard protocol was adopted. Therefore different approaches could not be easily merged into one common protocol for data quality control. Furthermore, quality checking methods were often combined with each other. Nevertheless, most of the countries reported visual or logical steps for quality checking. Few countries reported statistical or spatial approaches. A flagging system was not a commonly accepted system to identify suspicious data. Spatial control ranged from the simple comparison of the data to more elaborate methods of evaluating the data in space. A few countries were in the process of developing their own QC procedures. Analysis of the results revealed that a lot of attention was paid to the estimation of individual data and therefore the need for a very experienced phenologist and exact rules seem to be more than necessary (details in the final report from WG 2 of COST 725 Evolution of a European phenological database).

Establishment and maintenance of a European phenological database

ZAMG agreed to provide the complete hardware and software with WEB access and the human resources for development, analysis and maintenance of the complete database. After having agreed on a list of selected plants and phases for the common database at the MCM and WG workshops in Vienna, April 2005 data collection could start. It turned out that this was the most challenging task.

At the WG2 workshop in Ljubljana in 2007 the chair of WG 2 Wolfgang Lipa presented an interface based on PhP/Myadmin for data cess. In a second step Bogo Habic started to develop a more user-friendly system during an STSM in Vienna in March 2008.

The database consists of the phenological data table and several metadata tables describing information related to the stations, the phase codes of plants and information about the flagging system (figure 6).

The data table is as follows:

- The **pheno_data** table relates specifically to the phenological observation data, i.e. which phenological development stage of which plant (phase_id) was observed in which year (year) when (DOY day of year in which year and on which day of the year and where

The metadata tables are as follows:

- the **pheno_stat** table contains information relating to the physical location of the station in question
- the **country_code** table relates specifically to the countryname and id
- the **phase_code** table contains informations on the plants and phases.

The flagging metadata tables are as follows:

- The **flag_national** table relates to the national flagging system, which is specific for each country
- The **flag_serial** table relates to outliers in a time series
- The **flag_spatial** table relates to outliers on a spatial scale

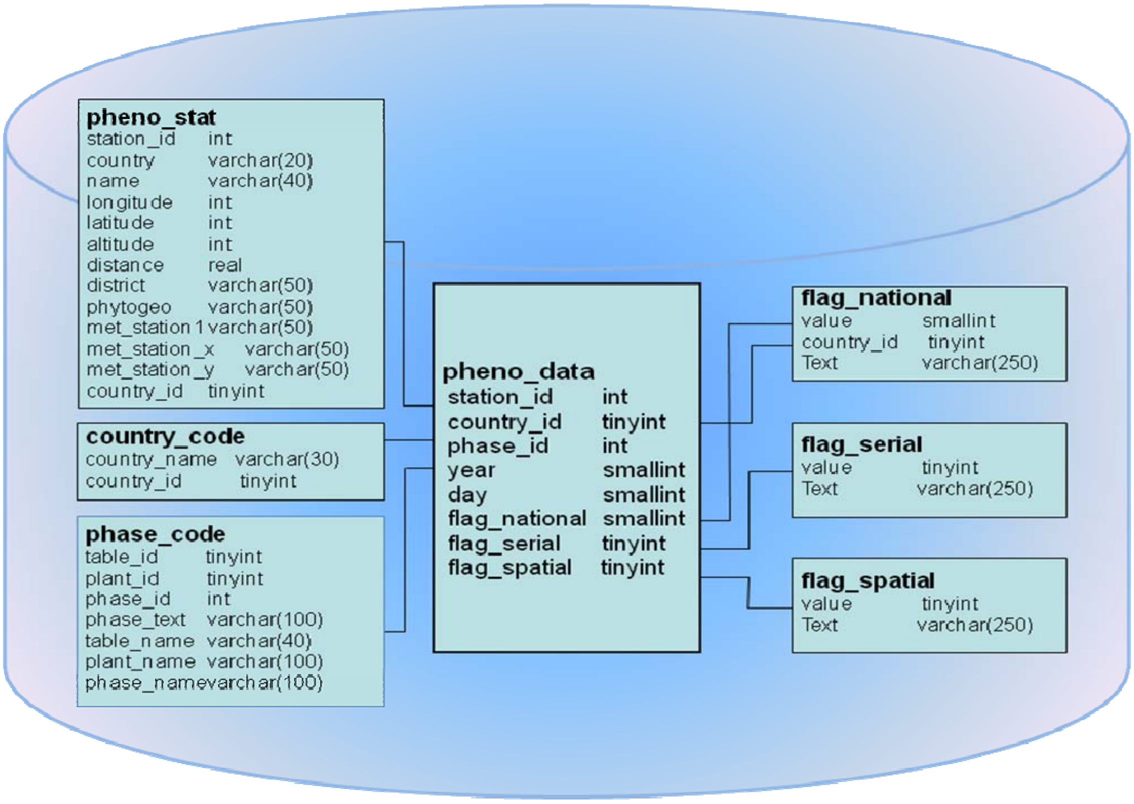


Figure 6: Schematic diagram of the European phenological database showing the various tables and their interrelationships.

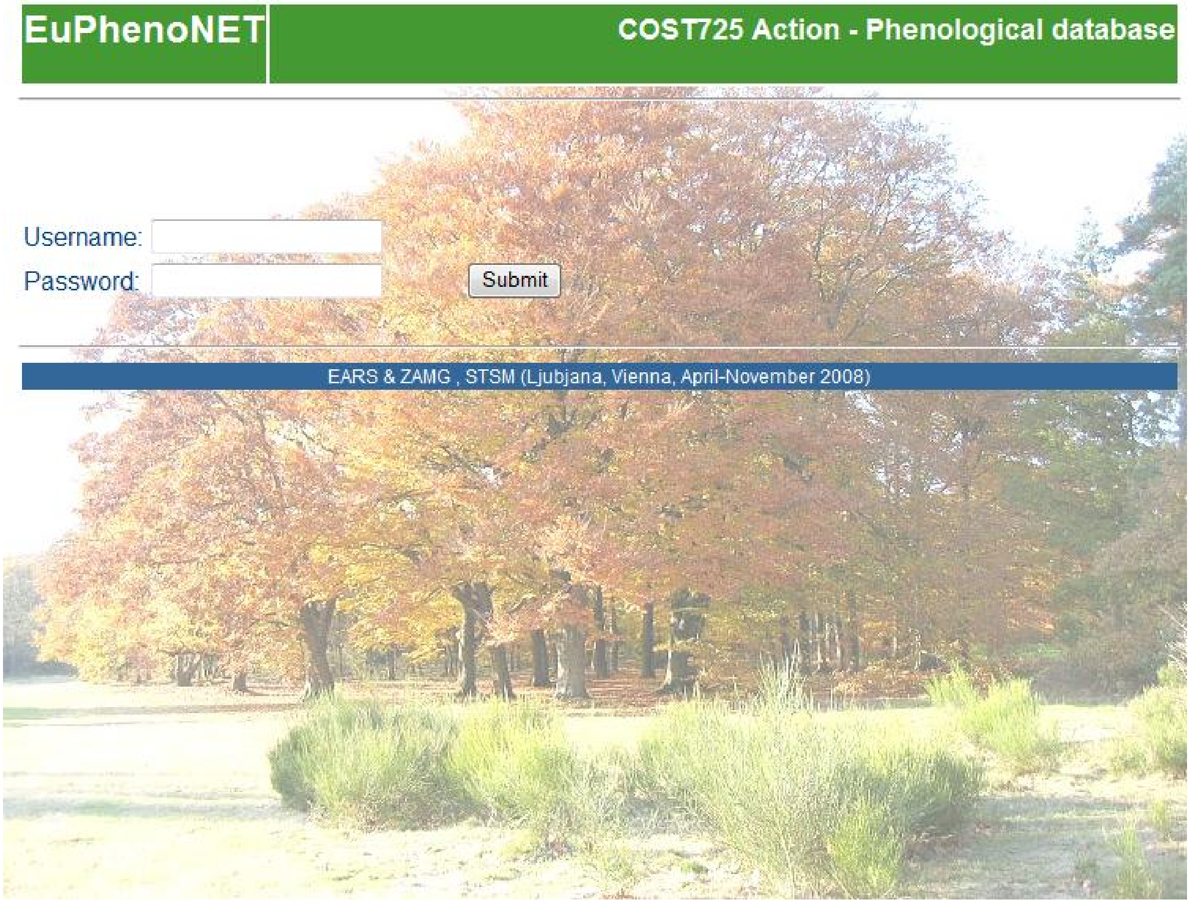


Figure 7: Entry page to COST725 phenological database

The MySQL database is running on a Linux server at ZAMG. Access to the EuPhenoNet contents is authorized and performed through a login page (figure 7). The database administration and user authorization are performed by a database administrator of ZAMG.

The webpage offers a data overview where users can have a quick look of site-specific data availability over selected period (countries / stations / plants) and basic statistics for the chosen data in tables, a graphical presentation of the data is also provided (figure 8). A dynamic menu-bar enables users to download data in selected charts or in delimited text files.

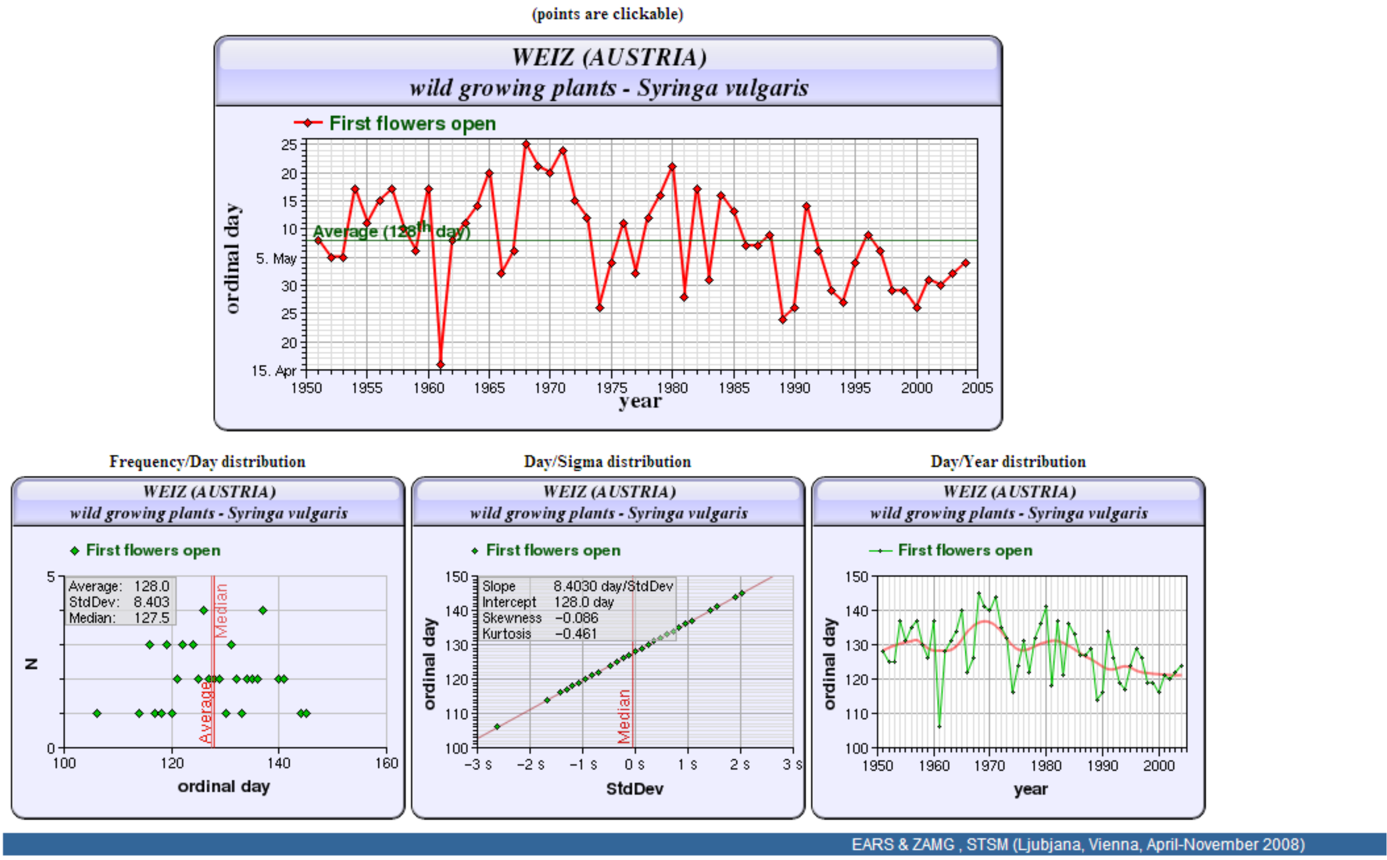


Figure 8: statistics from www.zamg.ac.at/cost725

2.3. WG3 Applications of phenological data, especially in climate change research

Working Group 3 was chaired by Annette Menzel (assisted by Nicole Estrella) from the TU Munich, Germany, and Tim H. Sparks from CEH, Monks Wood, UK.

Members of the WG3 and invited experts developed and tested several application activities on how to use phenological data and especially the reference data set, resulting from the Action. The scientific fields of interest under consideration were (A) Data Quality Control, especially cross border issues, (B) Mapping of phenological phases including interpolation, (C) Gridding, (D) Correlation of phenological data with climate data, various climate and circulation indices, (E) Trend analyses including uncertainty tests, (F) Phenological Modelling, (G) Microclimate and local effects as well as (H) Remote sensing applications. The results achieved in the different sub-activities, however, mainly depended on the possibilities to get national funding for distinct research projects. Within the COST action, especially the STSMs proved to constitute a valuable tool to strengthen inter-disciplinary and international research initiatives.

As phenology is probably the simplest process by which to track changes in the ecology of species in response to climate change, this field of detection and attribution of climate changes impacts in nature gained enormous attention in science and by the public.

Many studies in Europe and North America have already revealed phenological trends that very likely reflect responses to recent climate change. The timing of spring activities of plants in particular show an advance to earlier dates (mostly depending on temperature increase). The effect of a future climate with possibly even higher temperatures and changed precipitation patterns on the biosphere constitutes one of the greatest concerns of the climate impact community. Here, the greatest success of WG 3 of COST725 started.

COST725 'Meta analysis', a major contribution to IPCC, AR4, WG II report

At the workshop of COST725 in fall 2005 Annette Menzel from the Technical University Munich, Germany, chair of the WG3, proposed the idea of a European phenological "meta" analysis. The response to her request for contributions of the COST725 participating countries was enormous. During a Short Time Scientific Mission funded by COST, Menzel and her co-chair of WG3, Tim H. Sparks from the CEH Monks Wood, UK, analysed the national reports. Shortly after that, in 2006 the COST725 study

“European phenological response to climate change matches the warming pattern, Global Change Biology 12, 1969–1976”

Menzel, A., T. H. Sparks, N. Estrella, E. Koch, A. Aasa, R. Ahas, K. Alm-Kübler, P. Bissolli, O. Braslavská, A. Briede, F. M. Chmielewski, Z. Crepinsek, Y. Curnel, Å. Dahl, C. Defila, A. Donnelly, Y. Filella, K. Jatczak, F. Måge, A. Mestre, Ø. Nordli, J. Peñuelas, P. Pirinen, V. Remisová, H. Scheifinger, M. Striz, A. Susnik, F.-E. Wielgolaski, A. v. Vliet, S. Zach, A. Zust

was published and found immediately a European wide recognition (e.g. BBC news, CORDIS news). This publication was the basis for many articles in newspapers, magazines and the Internet on global climate change and phenological reactions. Even television seized the topic and produced some trailer on phenology. The summary of the results of this paper were included in a BOX (figure 9) in IPCC forth assessment report of chapter 1 of WG2 (2007).

Chapter 1 Assessment of observed changes and responses in natural and managed systems

Box 1.3. Phenological responses to climate in Europe: the COST725 project

The COST725 meta-analysis project used a very large phenological network of more than 125,000 observational series of various phases in 542 plant and 19 animal species in 21 European countries, for the period 1971 to 2000. The time-series were systematically (re-)analysed for trends in order to track and quantify phenological responses to changing climate. The advantage of this study is its inclusion of multiple verified nationally reported trends at single sites and/or for selected species, which individually may be biased towards predominant reporting of climate-change-induced impacts. Overall, the phenology of the species (254 national series) was responsive to temperature of the preceding month, with spring/summer phases advancing on average by 2.5 days/°C and leaf colouring/fall being delayed by 1.0 day/°C.

The aggregation of more than 100,000 trends revealed a clear signal across Europe of changing spring phenology with 78% of leaf unfolding and flowering records advancing (31% significantly (sig.)) and only 22% delayed (3% sig.) (Figure 1.6). Fruit ripening was mostly advanced (75% advancing, 25% sig.; 25% delayed, 3% sig.). The signal in farmers' activities was generally smaller (57% advancing, 13% sig.; 43% delayed, 6% sig.). Autumn trends (leaf colouring/fall) were not as strong. Spring and summer exhibited a clear advance by 2.5 days/decade in Europe, mean autumn trends were close to zero, but suggested more of a delay when the average trend per country was examined (1.3 days/decade).

The patterns of observed changes in spring (leafing, flowering and animal phases) were spatially consistent and matched measured national warming across 19 European countries (correlation = –0.69, $P < 0.001$); thus the phenological evidence quantitatively mirrors regional climate warming. The COST725 results assessed the possible lack of evidence at a continental scale as 20%, since about 80% of spring/summer phases were found to be advancing. The findings strongly support previous studies in Europe, confirming them as free from bias towards reporting global climate change impacts (Menzel et al., 2006b).

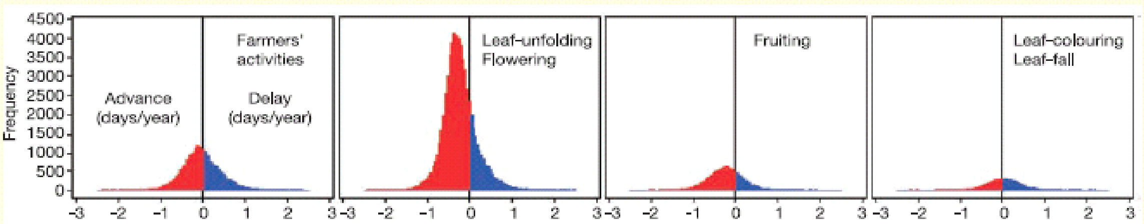


Figure 1.6. *Frequency distributions of trends in phenology (in days/year) over 1971 to 2000 for 542 plant species in 21 European countries. From Menzel et al. (2006b).*

Figure 9: Box showing results of COST725 data analyses of Menzel et al. GCB 2006, published in AR4 WGII chapter 1 IPCC 2007.

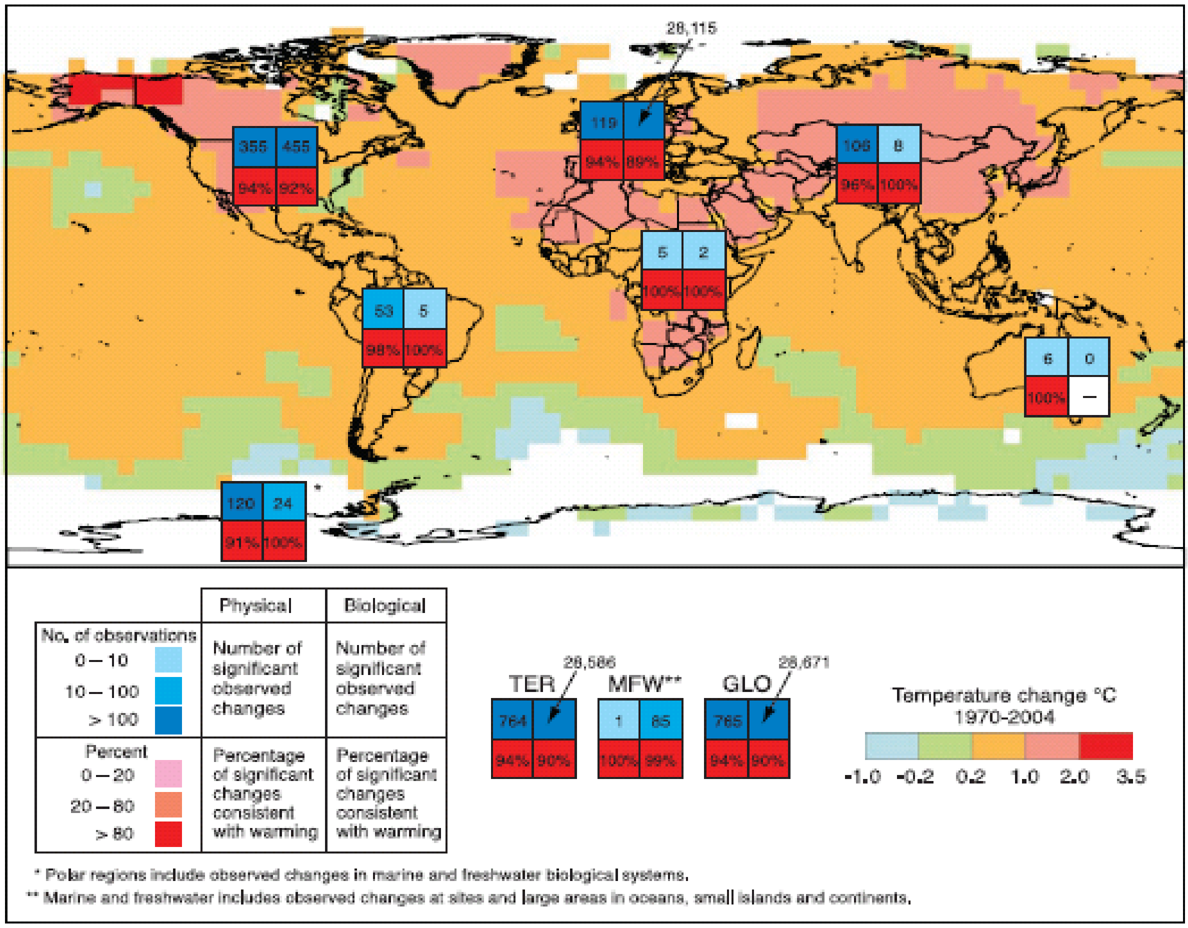


Figure 10: Summary of about 75 studies (of which ~70 are new since the Third Assessment Report), they contain about 29,000 data series, of which about 28,000 are from European studies. Published in AR4, WG2, SPM, IPCC 2007.

In the **IPCC AR4 WG II** report the COST725 study is one of the major contributions for the assessment of observed changes and responses in natural and managed systems, using 125 000 observational series of 542 plant and 19 animal species in 21 European countries for the period 1971-2000. The aggregation of the time series revealed a strong signal across Europe of changing spring and summer phenology: Spring and summer exhibited a clear advance by 2.5 days/decade in Europe. Mean autumn trends were close to zero, but suggested more of a delay when the average trend per country was examined (1.3 days/decade). The patterns of observed changes in spring (leafing, flowering and animal phases) were spatially consistent and matched measured national warming across 19 European countries; thus the phenological evidence quantitatively mirrors regional climate warming. The COST725 results assessed the possible lack of evidence at a continental scale as 20%, since about 80% of spring/summer phases were found to be advancing. The findings strongly support previous studies in Europe, confirming them as free from bias towards reporting global climate change impacts.

The strong expertise of COST725 members in assessing climate change responses in wild plants, agricultural systems and animals is also demonstrated by 4 COST members being part of the IPCC AR4 WGII Chapter 1 writing team (Lead authors Annette Menzel (Germany), Bernard Seguin (France), Contributing authors Nicole Estrella (Germany), Tim Sparks (UK)). Here, the value of phenological trends for climate change research due to the data base of COST725 could be promoted.

The enormous value of the COST725 database for climate change impact studies is demonstrated in figure 10. COST725 was the largest contribution of time series of observed changes within the Assessment of observed changes and responses in natural and managed systems (Chapter 01, WGII, AR4 of IPCC). The overwhelming number of phenological time series aggregated in COST725 is apparent, around

28000 time series out of almost 29000 global time series originated from the COST725 database. Furthermore the COST725 data were used in a global study of "Attributing physical and biological impacts to anthropogenic climate change" published in Nature (Rosenzweig et al. 2008)[3]. The European biological impacts were evaluated through more than 28,000 time series from 1971 - 2000.

STSMs

The use of STSMs proved to be very successful to facilitate scientific communication and work. The STSMs organised by WG3 lead to peer-reviewed publications in prestigious journals. The collaboration of A. Caffara (Ireland) and I. Chuine (France), supported by a STSM at the CNRS Montpellier in 2005, facilitated the phenological modelling part in the PhD of A. Caffara. The STSM of C. Schleip (TUM, Germany), visiting T. Rutishauser in Bern at the Geographic Institute, brought two young scientists working on their PhD theses together who then developed innovative applications of phenological data. These techniques are combined in the article "Time series modelling and central European temperature impact assessment of phenological records over the last 250 years" (Schleip, C., Rutishauser, T., Luterbacher, J., Menzel, A.) published 2008 in the Journal of Geophysical Research- Biogeosciences. C. Ziello (TUM) spent 10 days in 2008 at the Istituto Agrario San Michele all'Adige - IASMA. There she worked together with A. Caffarra on modelling phenological flowering phases. C. Ziello will incorporate the results in her further work. During the COST 725 STSM of N. Meier (Switzerland) in Barcelona, the potential of Principal Component Analysis (PCA) for various applications in phenological research was discussed with T. Rutishauser, e.g. PCA-based gap-filling techniques of phenological time series, the analysis of spatial differences of phenological variability and change as well as combined signal detection from multi-species data sets for climatological applications (see figure 11).

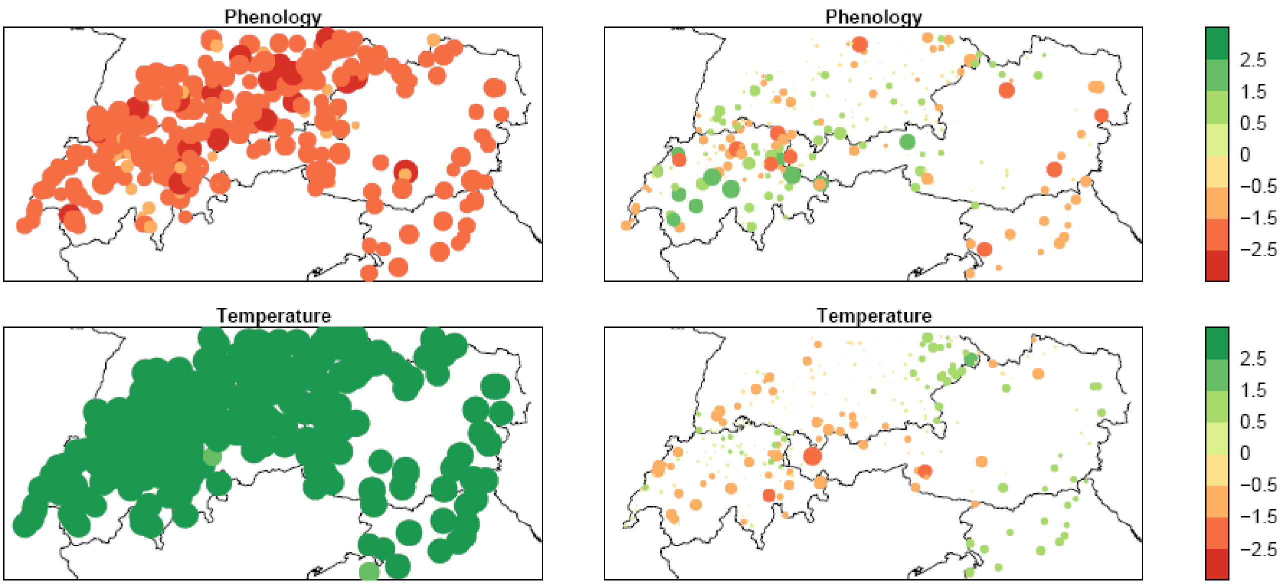


Figure 11: First and second PCA spatial pattern for phenology in days and for temperature in growing degree days. Color codes refer to a rough measure of the mean change in days per decade (see labels) and the sizes of the dots indicate relative strength within each group of color code (Meier et al. (in prep.)).

[3] Rosenzweig, C. et al. (2008) Attributing physical and biological impacts to anthropogenic climate change. Nature 453, 353-357

Workshops of WG3

WG3 organised two Workshops. The first took place 2006 in Dublin, where not only applications of phenological data, but also the first procedures of handling raw data were addressed. Participants discussed experiences with data quality and checking in different countries, because without the knowledge of the applied procedures further applications are hard to employ. National trend analyses (e.g. "Trend analysis of some long phenological records in Spain" from A. Mestre) and climatic influences on phenological onset dates (e.g. "Correlations and trend analyses of phenology in relation to temperature" F.E. Wiegolaski et al.) completed the overview of the work of workshop participants.

The second workshop of WG3 was held in Freising in 2007. 14 scientists, 10 from the COST725 action as well as 4 invited experts, participated and discussed applications, interpolations, analyses and mapping of phenological data. The presentations covered phenological aspects in the area of remote sensing, historical phenology, phenological modelling, correlation with climate data, trend analyses and mapping and gridding. Various scientists showed their applications of the unique dataset gathered from the action, the COST725 database. In addition to the time series in the COST725 database the value of historical phenological data were pointed out by talks by G. Demarée, T. Rutishauser and F. E. Wielgolawski, who presented the status-quo and possible applications in the field of historical phenology (paleoclimatology). Phenological data can be used as a proxy for temperature and therefore , long term phenological records provide necessary information of temporal variability phenological events in order to assess changes due to the anthropogenic greenhouse effect.

The session on correlation with climate data dealt with climatic influences and triggers of phenological events. There was an active discussion on geographical variations of the temperature response and the influence on farmers decisions on agricultural events (false- true phases). The article "Trends and temperature response in the phenology of crops in Germany" published 2007 in Global Change Biology by N. Estrella T. Sparks and A. Menzel comprised the suggestions of the discussion.

Special issue in Climate Research

During the Freising workshop the idea of a peer reviewed special issue in a scientific journal could be implemented to encourage further collaboration in scientific analyses of the COST725 data. The guidelines for articles published in this special issue are that at least two participating countries provide authors and data. The journal 'Climate Research' was very interested and accepted to publish the COST725 special issue. This special issue will be released in 2009. 11 papers have been submitted. Different aspects of applications of phenological observations will be covered.

Outreach

Members of WG3 maintained intense cooperations with the other two WGs, Workshops were attended and the data quality and collecting program were discussed. In total, the work of WG3 improved the knowledge of climate change impacts in nature and plant responses. The results of the outcomes build a solid base for further climate impact research in Europe. The development of several new applications was enabled with the phenological COST725 database. Overall the outreach was convincing, WG3 was very successful during the course of the Action as attested by the number of scientific publications as well as of the reports in the media. WG3 demonstrated effectively the value of phenological applications for climate impact research and was able to improve the importance of phenology in the public and scientific community.

3. Links with other COST actions and with ESF

There was close collaboration with ESSEM Action ES0603 Assessment of Production, Release, Distribution and Health Impact of Allergenic Pollen in Europe (EUPOL) and ESSEM Action 734 Impacts of Climate Change and Variability on European Agriculture: CLIVAGRI. The final conference of COST725 was a collaboration of these three actions a fact that is reflected by the conference program. Out of 50 presentations 10 stem from ES0603 and 6 from action 734. The COST725 MC member N. Dalezios organized an "Exploratory Workshop on Phenology and Agroclimatology" in Volos 21 – 23 September 2006, sponsored by ESF (http://www.esf.org/activities/exploratory-workshops/workshops-list.html?year=2006&domain).

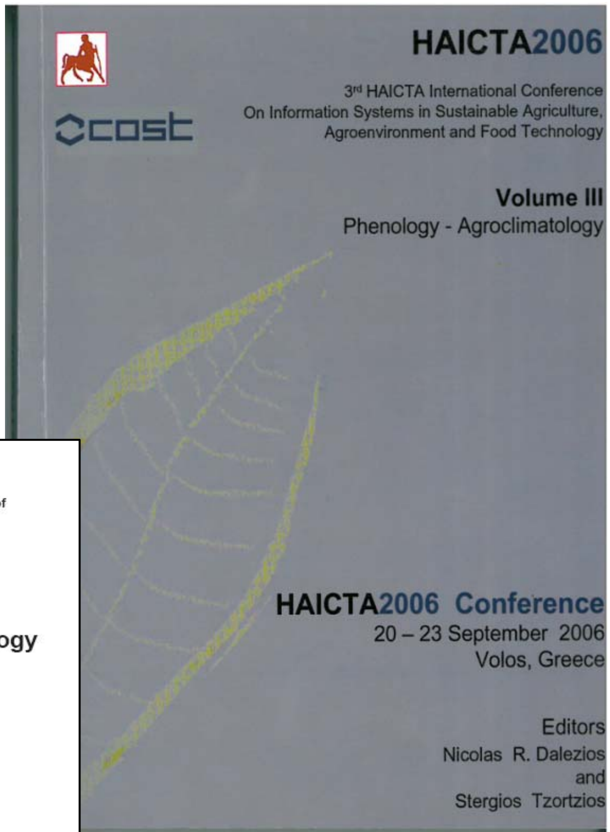
Many COST725 members were invited experts and participated actively. The outputs and recommendations of the workshop triggered many activities in the phenological landscape of Europe: the field of historical phenology worked out some fruitful ideas that were put to reality by national programs as for instance BACCHUS in Austria and OPHELIA in France. Due to the strong correlation between phenological spring phases and temperature in temperate and cool climate zones historical phenological data can be used as proxies for temperature reconstruction in the pre-instrumental era.

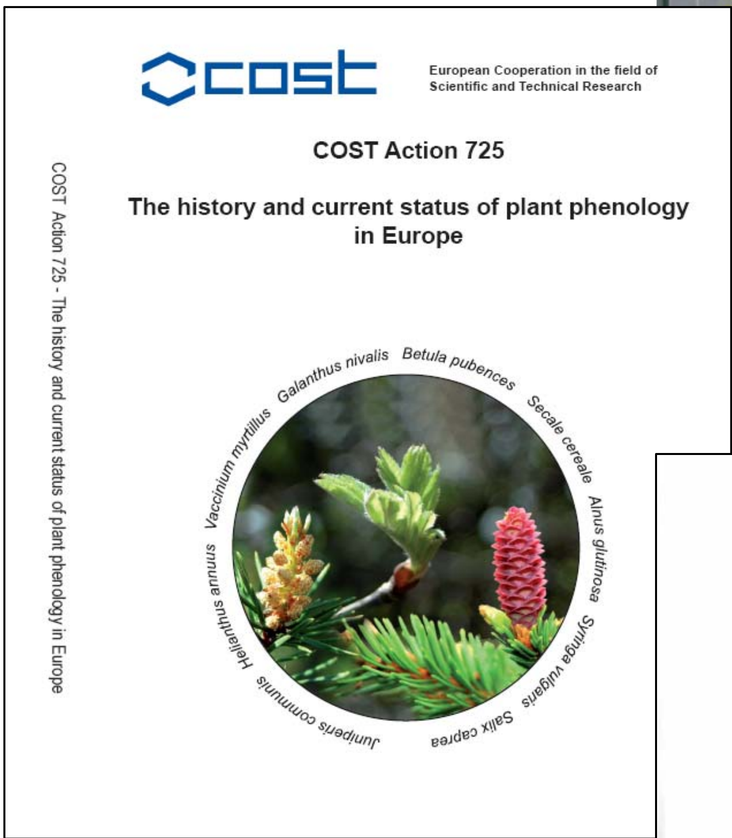
4. European added value

By organizing workshops, conferences and meetings (list of conferences and workshops in Annex), by financing STSMs and publications the COST framework achieved the following:

- Bringing Europe in top position of phenological research: 4 COST725 members being part of the IPCC AR4 WGII
- The standardising of phenological observation methods in Europe: all participating organisations applied the BBCH classification to the observed phenological events in their countries making the observations comparable
- The developing of common data quality checking routines: the survey of the different data checking procedures among the phenological network operators was a valuable input
- The creating of a European wide database with one single web-entry: access to more than 8000 observation sites from 20 European countries from 1951 onwards
- The publishing of European wide pheno-climate studies: a special issue of Climate Research is in preparation, the COST725 metastudy **European phenological response to climate change matches the warming pattern, Global Change Biology 12, 1969–1976**, a special issue of the "Italian Journal of Agrometeorology", "The history and present status of plant phenology in Europe
- The spinning off of new international projects
  - GEO group on earth observation: sub task Number US-09-03d: Global Phenology Data: coordination of phenological networks around the globe to establish one single data access to phenological data
  - PEP725: Pan European Phenologcal Database: follow up project of COST725, financed by EUMETNET, duration 5 years
- The spinning off of new of national projects and activities:
  - Austria: ZAMG, the national meteorological service and the Ministry of Science and Reserach are funding 3 phenological projects: PDR-QC (Phenological data rescue and quality checking), BACCHUS I and II (retrieving historical grape harvest dates from archives for temperature reconstruction into the pre-instrumental era) www.zamg.ac.at/phaenologie
  - Belgium: the RMI Royal Meteorological Institute has been making Belgian historical phenological data available in Computer Readable Form
  - Czech Republic: CMHI development of a new phenological database
  - Hungary: attempts to re-establishing the phenological network, which was closed in the 1990s.
  - Ireland: a 3-year project which began in April 2008, has €1M funding and is based in the Centre for the Environment in the School of Natural Sciences in Trinity College Dublin.
  - Latvia, University of Latvia development of a database, photo monitoring sites with web-cameras are being established in Latvia (www.botanika.lv).
  - The Netherlands, University Wageningen: digitization of historical phenological data, improvement of the methodologies for monitoring, raising of additional national and bi-national funding, development of educational programs, digitalization of old records.
  - Norway: Meteorological Institute collection and utilization of phenological observations at some meteorological stations with the purpose of getting input data for numerical weather models.
  - Slovenia: EARS newly established Project: "Climate variability in Slovenia" with a special study on phenology and its

variability due to climate variability and climate change.
  - Sweden: development of a national phenological network, initiation of a Nordic collaboration CANOPY (Collaboration Action on NOrdic PhenologY)
- the exchange of knowledge: 4 international conferences were (co-)organized
- the promotion of young scientists: 25% of the MC are early stage researchers, mainly young scientists took part at the STSMs
- gender mainstreaming: 16 members of the MC (out of 47) are women, the MC of the action and WG1 were chaired by women





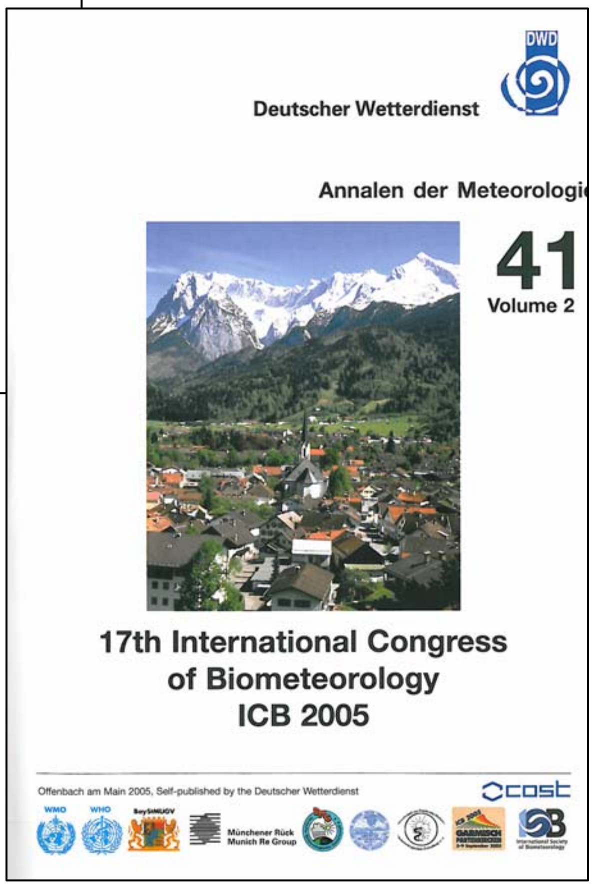


Figure 12: Selected contribution of the COST 725 program to developments in different European member states

5. National Contributions:

5.1. Austria

Elisabeth Koch, Zentralanstalt für Meteorologie und Geodynamik (ZAMG)

The Austrian programme within COST725 was the establishment of a webportal of Austrian phenology making all observational data stored at ZAMG available to endusers and enabling online data-entry for Austrian phenological observers.

Projects were funded to digitize the historic ZAMG phenology paper archive and to enable an interdisciplinary study of historians and climatologists where historic grape harvest dates from original historic sources were assessed and evaluated. As the GHD and the mean temperatures from April to July are strongly correlated we were able to reconstruct temperatures back to the 16th century for the Viennese region. And last but not least ZAMG has been developing hosting and maintaining COST725 database. www.zamg.ac.at/cost725

5.2. Belgium

Gaston Demarée, the Royal Meteorological Institute of Belgium (RMIB)

The contribution of the Belgian COST725 participant at the Royal Meteorological Institute of Belgium, consisted mainly of making Belgian historical phenological data available in Computer Readable Form (CRF). This work was done using the paper archives stored in the RMIB.

Several long-term records from the phenological network of the RMIB were selected. The network was created in 1943 under conditions of the Second World War and lasted until 1977. Unfortunately, very few observers cooperated for a longer period. The station at Leopoldsburg was only selected for its phenological observations of the cold winters of the 1960s although the series lasted only one decade. Fortunately, a very dedicated observer, Mr. Louis Glibert at Blanmont in the Brabant Walloon, continued his observations after the closure of the network until the end of the century.

Information on the following growth stages: first flowering, full flowering, leaf unfolding, first ripe fruits and leaf-fall of at the most 35 plants was collected by each observer in the vicinity of their site. Only the form A was used here; the other forms deal with cereals, fruit trees, diseases and weather related issues.

Although the phenological documents remained unused half a century in the "archives" of the RMIB, there has been keen interest in the newly produced excel files. The dataset was already transferred to the COST725 phenological database at ZAMG in Vienna, to the Fachgebiet für Ökoklimatologie at the Technische Universität München, to the CEFE-CNRS at Montpellier and to the Universiteit Antwerpen, Ministry of the Flemish Community.

5.3. Czech Republic

Martin Striz, Czech Hydro Meteorological Institute (CHMI)

Phenological information has been collected and recorded in paper form for many years. In 2003 CHMI started to develop a new phenological database (Oracle). The data are quality checked for the following: correct date format, sequence of phenological phases, basic statistical control (standard deviation). A web based application for viewing and quality control checking has been used in the NHMI intranet since 2007.

5.4. Ireland

Alison Donnelly, School of Natural Sciences, Trinity College Dublin, Ireland.

The involvement of Ireland in COST725 WG2 proved invaluable for gaining national funding to establish a specialised research group to investigate the impacts of climate change on phenology and its implications for terrestrial ecosystems. In addition, Ireland has forged strong international collaborative links which will continue into the future. Finally, participation in this Action has resulted in Ireland being part of several peer-reviewed scientific publications.

At the beginning of this EU COST Action 725 on 'Establishing a European Phenological Data Platform for Climatological Applications' Irelands contribution was through its involvement in the International Phenological Gardens network. However, since joining COST725 Ireland has been hugely successful in raising awareness and demonstrating the importance of phenological data to both the scientific community and the general public. This success was achieved through (a) collaboration with colleagues at a European level and (b) the exchange of knowledge from established experts.

In April 2006 the management committee meeting was held in Trinity College Dublin and sponsored by the Environmental Protection Agency (EPA). This demonstrated to the University and the EPA the potential for international collaboration through such an Action.

Ireland benefited from 2 Short Term Scientific Missions which were carried out in collaboration with WG3 under the guidance of Isabelle Chuine in Montpellier, France. As a result of these STSMs one scientific paper is in press and another is being prepared for submission (see WG3).

Two Small Scale Studies, funded by the Irish Environmental Protection Agency were carried out and the involvement of Ireland in COST725 proved invaluable for gaining national funding from the Environmental Protection Agency (Ireland) to establish a specialised research group to investigate the impacts of climate change on phenology and its implications for terrestrial ecosystems. This is a 3-year project which began in April 2008, has €1M funding and is based in the Centre for the Environment in the School of Natural Sciences in Trinity College Dublin, Ireland.

5.5. Latvia

Agrita Briede and Gunta Kalvane, University of Latvia

Participation in COST725 enabled the development of a database and included collection of metadata for the stations, use of the BBCH code system and data quality checking.

Other experience gained from participation in the project were data statistical analyses which resulted in the publication of an article in a scientific journal. Another experience obtained during this project was based on the ability to use these data for climate change studies. In addition, the COST725 meetings facilitated useful discussion on phenological topics, in particular, on photo monitoring which resulted in three photo monitoring sites with web-cameras being established in Latvia (www.botanika.lv).

5.6. The Netherlands

Arnold J.H. van Vliet and Sara Mulder, Environmental Systems Analysis Group, Wageningen University

The COST725 program had a significant impact on the developments of the Dutch phenological network Natuurkalender (Nature's Calendar) in recent years. Through international cooperation and regular meetings we were able to improve the network in various ways. We improved the methodologies for monitoring of phenological events and analysis of data. The development of the European reference database stimulated the digitization of thousands of historic phenological observations. By providing an overview of the lists of species and phenophases in the different countries we decided to expand our observations program. We added several plant species that were selected for the European reference database but that were not yet included in the Dutch monitoring program. Furthermore, we decided to add an agricultural section to our network by including a large number of crops and fruit species. The inclusion of these agricultural species resulted in a large number of new contacts and partners within The Netherlands.

The European cooperation strongly supported our efforts to get additional funding for the coordination of the Dutch phenological network. Several national programs, mainly on climate change, decided to fund our work. The regular meetings with our European colleagues also significantly stimulated the generation of new ideas. Especially in the fields of developing applications for phenological networks strong developments have taken place. In the context of the human health sector we focused on three topics: hay fever in relation to flowering of plants; the distribution and life cycle of the Oak processionary caterpillar, and the seasonal dynamics of ticks in relation to Lyme disease. Furthermore, the Dutch phenological program applied its phenological information for a decision support system that helps in deciding when different nature management activities can be executed. The system determines when species are in their vulnerable period. Finally, we have further developed our educational program for school children. This educational program allows school children to participate in the monitoring program.

5.7. Norway

Frans Emil Wielgolaski, University of Oslo, Finn Mage, Norwegian University of Life Sciences, Oyvind Nordli, Norwegian Meteorological Institute

Some benefits of the Norwegian participation in the COST725 on phenology are as follows: Phenological data from two Norwegian phenological gardens as well as long series from two fruit gardens were analysed and the results published in Int. J. Biometeorol.

Besides interesting results from the analyses themselves a side effect of this common effort, was also a closer co-operation between institutions involved in phenology. These were: The University of Oslo and the University of Life Science, The Northern Research Institute Tromsø (NORUT), The Meteorological Institute as well as the institute for Agricultural and Environmental Research. The latter institution is in charge of one of the International Phenological Gardens (IPG) in Norway, while another is taken care of by the Norwegian Forestry and Landscape Institute. This national effort as well as the effort generated by the COST action has lead to a more thorough quality control of the phenological observations in Norway, in the IPGs as well as in the fruit gardens.

As a result of the COST action Norway was able to send quality controlled data to the COST database.

In 2004 The Norwegian Meteorological Institute took an initiative to collect phenological observations at some of its meteorological stations with the purpose of getting input data for models, i.e. a model for the probability of forest fire. By this COST action the observations were also integrated in the national network of phenological observations. That opens for a wider use of the data. The present status of the observations is that the occurrence of bud burst for birch trees at about 30 sites throughout Norway are registered.

In the teaching of students COST725 has led to more focus on phenology, and so has the importance of phenology in connection with climate change. This is also true for talks and more formal lectures on the aspect, partly based on personal observations. Some popular papers including phenology are written, and more are planned, also scientific ones, partly based on old Norwegian phenological long series material, all inspired by the COST 725.

In 2008 a paper on flowering in sweet cherries was written in Danish in a journal for Danish fruit growers: Finn Måge. 2008: Sødkirsebær blomstrer tidligere og tidligere (Sweet cherries flower earlier and earlier). *Frugt og Grønt*, Mai 2008, 242-243.

In February 2008 F.E. Wielgolaski gave an invited lecture in southern Sweden on “Plants and Climate” based on Norwegian phenological plant observations, for an audience planning a Swedish project on collecting plant phenological data in Sweden.

5.8. Slovenia

Ana Žust, Andreja Sušnik, Environmental Agency of the Republic of Slovenia

COST725 was a great challenge for Slovene phenological monitoring. We found most of the aims declared in COST725 mission in common, and joining the action was an important opportunity to upgrade experience and exchange views with other relevant monitoring agencies in Europe. Firstly, a decision of COST725 that all observed plants and phases have to be classified according to one guideline. The BBCH scale was crucial for the development of phenological monitoring in Slovenian. In Slovenia descriptive determination of phenological phases is common use for a long time. COST725 triggered the decision to transform phases into BBCH coding system and to incorporate them into the national phenology database structure. In this regard phenological monitoring gained remarkably in upgrading the exchange of data at both national and international level. Another great success of COST725 was the implementation of a decision to enable data management, visualisation and access of the Common European phenology data platform through Web portal (EuPhenoNET). Slovenia actively contributed in the creation of the Web portal and experience attained through this work will be implemented in creation of similar web portal for the national phenological database.

Studies based on unified European phenological data gave remarkable results and the study of European phenological response to climate change (COST725 box in IPCC, 4AR IPCC) attained worldwide recognition and in Slovenia as well. Results served as an important reference in the newly established Project: "Climate variability in Slovenia". In this project a special study will be devoted to phenology and its variability due to climate variability and climate change.

Finally, one important success of COST725 was the recommendation of the Comission for Climatology CCl of WMO to include phenological observations in the"Guide to Climatological Practices". This important progress in phenological monitoring at all and all other information sourced in COST725 action will be integrated in new Guidelines of Phenological observation in Slovenia and in Phenological Atlas which will be issued in the following year in Slovenia.

5.9. Sweden

Kjell Bolmgren, Åslög Dahl, Ola Langvall
Department of Botany, University of Stockholm

Until 2007, phenology observations in Sweden was carried out by single organizations for certain purposes, like pollen studies and forest phenolgy, and with limited spatial distribution. The knowledge of historical datasets was also limited.

However, during 2007 and early 2008, the plans to initiate a Swedish Phenology Network has was put into effect by the two COST-Action members Åslög Dahl and Ola Langvall, in cooperation with Kjell Bolmgren. This team planned and held a symposium in Alnarp, in southern Sweden, on February 7, 2008 entitled "Concerted action for phenology in Sweden". The symposium was financed by the Swedish Research Council Formas, and could therefore be held free of charge for the participants. The 50 participants were represented a wide range of organizations, including governmental agencies, non-governmental organizations, researchers, school project leaders, and many more with an interest in phenology. The symposium included some key-note speakers (e.g. two members from the COST-Action: Alison Donnelly and Frans Emil Wielgolaski) and a workshop concerning how a Swedish Phenology Network could be initiated. The outcome of the symposium was useful and provided the basis to establish the network. To get a head start, the decision was taken to launch a homepage, www.blommar.nu, for voluntary reporting of phenology, which was done in early March. The symposium was announced to the media, and to further increase the public interest in the voluntary activity, a certain domain name was introduced for reporting "signs of spring": www.vårtecken.nu. The activity was covered frequently by regional and national television, radio stations and newspapers for several weeks, as well as in more scientific papers (e.g. Dahl et. al., 2008). The success of this could be counted in the amount of voluntary reporting. In early May about 1700 reports were made for more than 250 different species by over 370 observers. Several historical datasets have also been discovered along the way, which can be used as references to recent reported data.

Sweden also initiated the Nordic collaboration CANOPY (Collaboration Action on NOrdic PhenologY) and is developing a platform for regional Swedish governmental agencies to use phenology as an environmental indicator in relation to Climate Change.

Reference

Dahl Å., Bolmgren K., Langvall O. 2008. Se klimatförändringen med egna ögon – gör fenologiska observationer! Svensk botanisk tidskrift vol 102 nr 1 19-26 (In Swedish).

6. Impact of COST725

The success of COST725 can be demonstrated through examination of the major outputs of the Action and its influence across the wider scientific community. The following is a brief summary of the main impacts of COST725.

The science of phenology is considered to have its origins in Europe which has a long tradition of phenological networks dating back to 1750. These networks evolved at different times and in different locations which resulted in the emergence of a diverse range of methodologies for recording of observations. This non-standardized approach presented difficulties for comparative data analysis at a pan-European level and therefore the use of changes in phenology as an indicator of the impact of global climate change on the European environment was a challenging task.

In addition to the fragmented nature of the phenological networks a wide range of guidelines for observations and data quality control were used across the different jurisdiction. One of the main outcomes of COST725 was to develop, in cooperation with the WMO, WCDMP and WCP, a standard set of 'guide-

lines for plant phenological observations' based on the BBCH code. The adoption of the BBCH coding scale for identification of phenophases allowed, for the first time, direct comparison across species and countries throughout Europe. Furthermore, the coding system was build into the COST725 reference database templates.
In their (soon to be published) Guide to Climatological Practices (3rd edition), the WMO's Commission for Climatology have included, for the first time, a recommendation to make phenological recordings. This outcome was a direct result of close cooperation with COST725.
Prior to the establishment of COST725 the International Phenological Gardens (IPG) network, which consists of approximately 50 sites, provided a limited opportunity to study phenology across Europe. With the incorporation of data from the IPGs and from almost all other phenological networks operating in Europe, including from countries not participating in the Action, the COST725 database has significantly expanded the range of data available to conduct research.
On a global scale, COST725 has forged close collaborations with the recently founded USA National Phenological Network and with 'Climate Watch' the first large scale phenology network in Australia. Climate Watch was initiated as a result of reporting by the IPCC 4th that observed changes in the Southern Hemisphere were limited.

Finally, the most significant output from COST725 was the publication of a study, by Annette Menzel, entitled 'European phenological response to climate change matches the warming pattern' which was summarized by the IPCC in their 4th Assessment Report. This ensured global recognition for the importance of phenological observations to climate research.

7. Dissemination of results

From the beginning of the action the co-chair of the MCM Arnold v. Vliet was responsible for www.cost725.org. This webpage not only shows the major outputs of the action but was also a communication tool for the COST members.

The COST office and the action chair presented COST725 at many conferences oral and poster presentation among others at 16th Conference Biometeorology and Aerobiology, 2004 in Vancouver, at the EGU general assembly 2005 in Vienna and at the 7th EMS/8th ECAM 2007 El Escorial - flyers of the action were distributed.
The aforementioned meta analyses received a lot of media attention.

The publications of WG1 "History and current status of plant phenology in Europe" and of WG2 "Evolution of a European phenological database: Final report from WG2 of COST725" were distributed to app. 500 people.

WG 3 members have been publishing in peer reviewed journals; a special issue of Climate Research is in press and will be published online with open access in 2009.

In Annex 2 the COST725 – related publication are listed.

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Spring springs earlier

[Date: 2006-08-25]

A pan-European study has found that spring is starting six to eight days earlier than 30 years ago. The authors believe the culprit to be global warming. In some more southern areas, such as Spain, spring begins a full two weeks earlier than 30 years ago.

© PatMcD

If William Wordsworth took his walk around the UK's Lake District that inspired his ode to springtime, 'Daffodils', some time around the end of March 1804, today he could have taken the same walk, and found his daffodils, around the beginning of March.

The study was led by Dr Tim Sparks of the Centre for Ecology and Hydrology in the UK and Dr Annette Menzel from the Technical University Munich in Germany. They coordinated a team in 21 countries between 1971 and 2000, looking at 125,000 sets of data, making the study the largest of its kind ever conducted.

The team investigated climate change by looking at phenological - naturally recurring - events. To do this, they examined the behaviour of 542 plant and 19 animal species during this time. 'Unlike some studies that record individual species, this is the first comprehensive examination of all available data at the continental scale, using around 550 plant species, and the timing change is clear, very clear,' said Dr Menzel.

The researchers found, '78 per cent of all leafing, flowering and fruiting records advanced (30 per cent significantly) and only 3 per cent were significantly delayed,' reads the report. They concluded that spring has been arriving earlier by an average of 2.5 days per decade during this time.

The study is unique in that the advance of spring has been linked explicitly to climate change for the first time. 'Our analysis of 254 mean national time series undoubtedly demonstrates that species' phenology is responsive to temperature of the preceding months,' reads the report.

'Not only do we clearly demonstrate change in the timing of seasons, but that change is much stronger in countries that have experienced more warming,' said Dr Sparks. 'Many plant species grow throughout Europe, so, for example, a direct comparison of the flowering date of wild cherry which is two weeks earlier in the UK with that in Austria which is only 3 days earlier is possible with this huge dataset.'

The study was funded by COST - European Cooperation in the field of Scientific Research - which is itself supported under the European Union's Sixth Framework Programme (FP6).

For further information, go to the Global Change Biology website at http://www.blackwell-synergy.com/loi/GCB

Visit the COST website at:
http://www.cost.esf.org/

Figure 13: CORDIS (http://cordis.europa.eu/fetch?CALLER=FP6_NEWS_COORD&ACTION=D&DOC=45&CAT=NEWS&QUERY=011f6e5b0e4f:6809:12fe6e2c&RCN=26226)

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Environment

Earlier springs and later autumns: climate change sends nature awry

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Buzz up!
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Ian Sample, science correspondent
The Guardian, Saturday 26 August 2006

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Spring is arriving earlier each year as a result of climate change, the first "conclusive proof" that global warming is altering the timing of the seasons, scientists announced yesterday.

In what is believed to be the world's largest study of seasonal events, such as the flowering of plants, autumnal leaf fall and insect behaviour, scientists found that spring now arrives six to eight days earlier across Europe than in the early 1970s. Warmer temperatures have also delayed autumn, by an average of three days in the past 30 years, the scientists report.

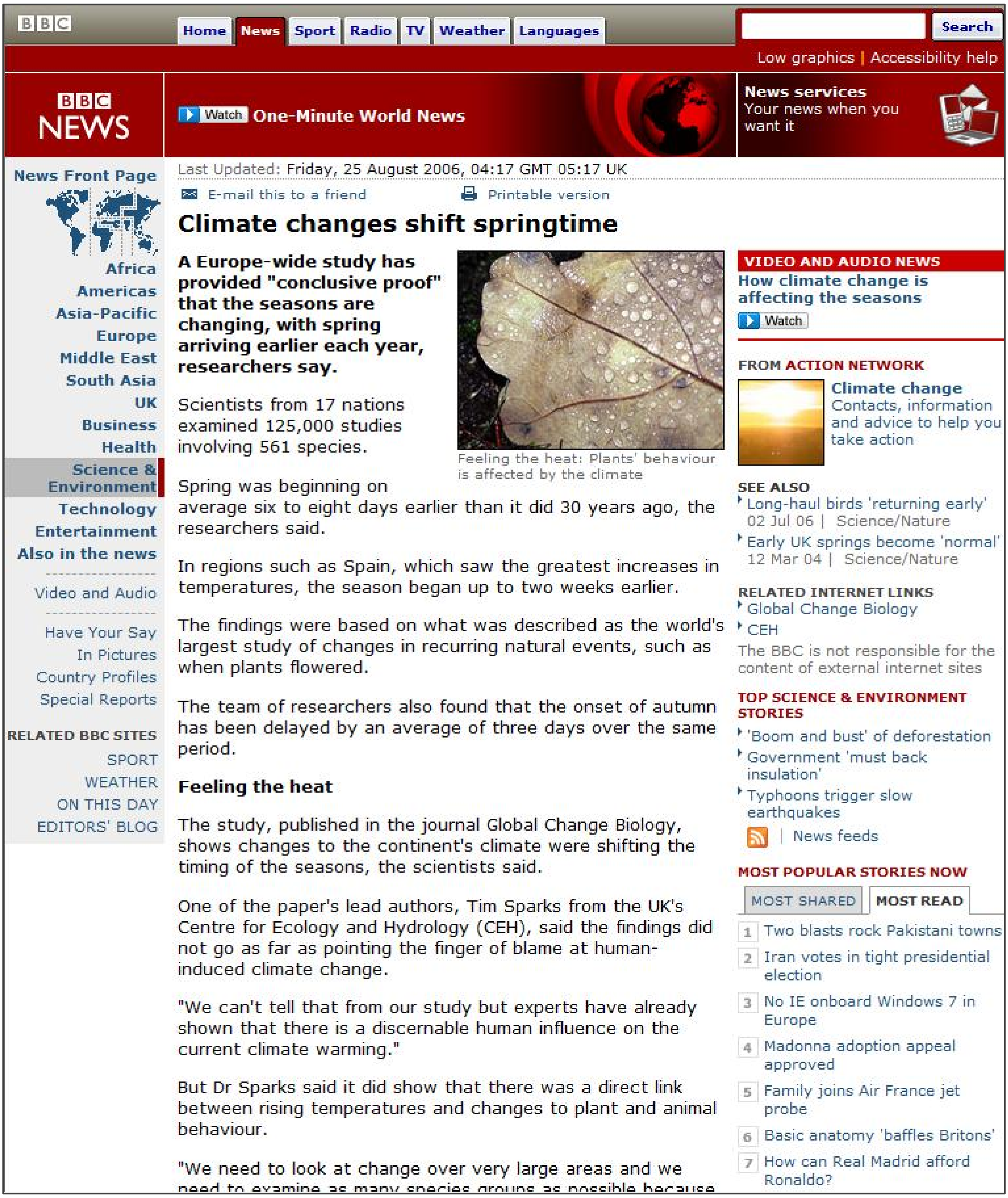
Countries that have experienced the greatest warming saw the earliest springs, according to the study in the journal Global Change Biology. In Spain, where early spring temperatures have risen by up to 1C a decade, spring now arrives two weeks earlier. Britain is warming at a slower rate, with temperatures creeping up 1C in the past three decades.

"Not only do we clearly demonstrate change in the timing of seasons, but that change is much stronger in countries that have experienced more warming," said Tim Sparks, an environmental scientist on the study at the Centre for Ecology and Hydrology at Monks Wood near Huntingdon. Dr Sparks said the shifting seasons were already disrupting sensitive ecosystems by knocking natural processes such as pollination out of kilter.

"One of the biggest problems is that species don't adapt to warming at the same rate. So if you have a bird that feeds on an insect that relies on a certain plant for food, and any one of those responds to warming differently to the others, the whole system can break down," he said.

Scientists from 17 countries took part in the study and analysed 125,000

Figure 14: The Guardian (http://www.guardian.co.uk/environment/2006/aug/26/climatechange.climatechangeenvironment)



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Climate changes shift springtime

A Europe-wide study has provided "conclusive proof" that the seasons are changing, with spring arriving earlier each year, researchers say.

Feeling the heat: Plants' behaviour is affected by the climate

Scientists from 17 nations examined 125,000 studies involving 561 species.

Spring was beginning on average six to eight days earlier than it did 30 years ago, the researchers said.

In regions such as Spain, which saw the greatest increases in temperatures, the season began up to two weeks earlier.

The findings were based on what was described as the world's largest study of changes in recurring natural events, such as when plants flowered.

The team of researchers also found that the onset of autumn has been delayed by an average of three days over the same period.

Feeling the heat

The study, published in the journal Global Change Biology, shows changes to the continent's climate were shifting the timing of the seasons, the scientists said.

One of the paper's lead authors, Tim Sparks from the UK's Centre for Ecology and Hydrology (CEH), said the findings did not go as far as pointing the finger of blame at human-induced climate change.

"We can't tell that from our study but experts have already shown that there is a discernable human influence on the current climate warming."

But Dr Sparks said it did show that there was a direct link between rising temperatures and changes to plant and animal behaviour.

"We need to look at change over very large areas and we need to examine as many species groups as possible because

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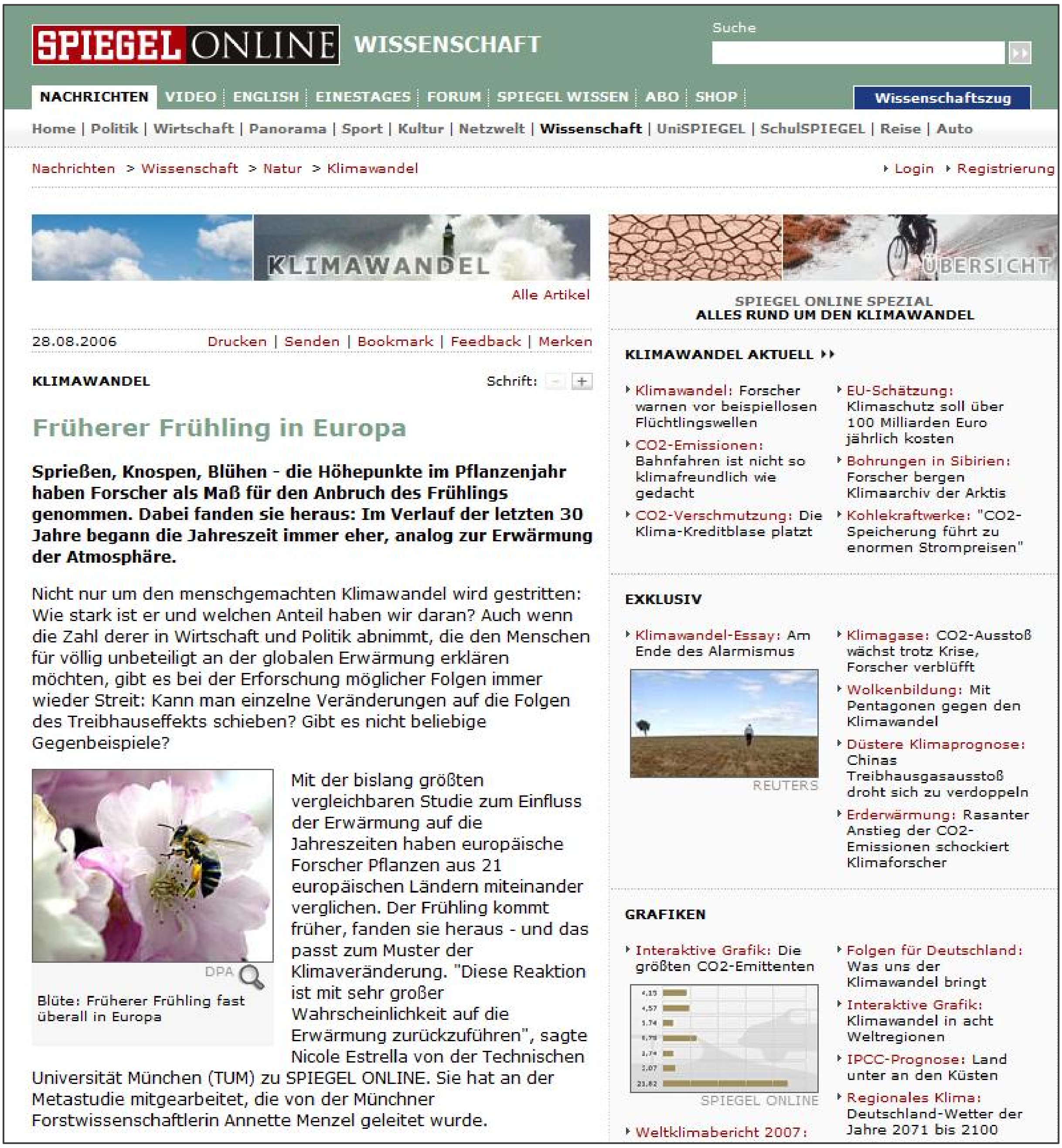
Figure 15: BBC News (http://news.bbc.co.uk/2/hi/science/nature/5279390.stm)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Früherer Frühling in Europa

Sprießen, Knospen, Blühen - die Höhepunkte im Pflanzenjahr haben Forscher als Maß für den Anbruch des Frühlings genommen. Dabei fanden sie heraus: Im Verlauf der letzten 30 Jahre begann die Jahreszeit immer eher, analog zur Erwärmung der Atmosphäre.

Nicht nur um den menschgemachten Klimawandel wird gestritten: Wie stark ist er und welchen Anteil haben wir daran? Auch wenn die Zahl derer in Wirtschaft und Politik abnimmt, die den Menschen für völlig unbeteiligt an der globalen Erwärmung erklären möchten, gibt es bei der Erforschung möglicher Folgen immer wieder Streit: Kann man einzelne Veränderungen auf die Folgen des Treibhauseffekts schieben? Gibt es nicht beliebige Gegenbeispiele?

DPA

Blüte: Früherer Frühling fast überall in Europa

Mit der bislang größten vergleichbaren Studie zum Einfluss der Erwärmung auf die Jahreszeiten haben europäische Forscher Pflanzen aus 21 europäischen Ländern miteinander verglichen. Der Frühling kommt früher, fanden sie heraus - und das passt zum Muster der Klimaveränderung. "Diese Reaktion ist mit sehr großer Wahrscheinlichkeit auf die Erwärmung zurückzuführen", sagte Nicole Estrella von der Technischen Universität München (TUM) zu SPIEGEL ONLINE. Sie hat an der Metastudie mitgearbeitet, die von der Münchner Forstwissenschaftlerin Annette Menzel geleitet wurde.

ÜBERSICHT

SPIEGEL ONLINE SPEZIAL
ALLES RUND UM DEN KLIMAWANDEL

KLIMAWANDEL AKTUELL

- Klimawandel: Forscher warnen vor beispiellosen Flüchtlingswellen
- CO2-Emissionen: Bahnfahren ist nicht so klimafreundlich wie gedacht
- CO2-Verschmutzung: Die Klima-Kreditblase platzt
- EU-Schätzung: Klimaschutz soll über 100 Milliarden Euro jährlich kosten
- Bohrungen in Sibirien: Forscher bergen Klimaarchiv der Arktis
- Kohlekraftwerke: "CO2-Speicherung führt zu enormen Strompreisen"

EXKLUSIV

- Klimawandel-Essay: Am Ende des Alarmismus

REUTERS

- Klimagase: CO2-Ausstoß wächst trotz Krise, Forscher verblüfft
- Wolkenbildung: Mit Pentagonen gegen den Klimawandel
- Düstere Klimaprognose: Chinas Treibhausgasausstoß droht sich zu verdoppeln
- Erderwärmung: Rasanter Anstieg der CO2-Emissionen schockiert Klimaforscher

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- Interaktive Grafik: Die größten CO2-Emittenten

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- Folgen für Deutschland: Was uns der Klimawandel bringt
- Interaktive Grafik: Klimawandel in acht Weltregionen
- IPCC-Prognose: Land unter an den Küsten
- Regionales Klima: Deutschland-Wetter der Jahre 2071 bis 2100

Figure 16: SPIEGEL Online (http://www.spiegel.de/wissenschaft/natur/0,1518,434003,00.html)

8. Outlook

To guarantee further cooperation of phenological network operators and the maintenance and regularly update of the COST725 database that serves as research infrastructure for the European scientific community especially for Climate Change research the chair of COST725 submitted the 5 years project proposal PEP725 (Pan European Phenological database) which was accepted by EUMETNET in May 2009. The project will provide a high quality data product across Europe based on the experience and knowledge of the participating countries / network operators and of the findings of COST725, and a user-friendly webpage for all those interested in nature. A new data quality checking routines will be introduced. After the Kick off workshop two more workshops will be organized and the findings of PEP725 will be presented at international conferences. PEP725 will start in 2010.

COST725/PEP725 will also be one of the leading partners of the new GEO-task: Global Phenology Data. Together with the USA National Phenology Network and the University of Milwaukee COST725/PEP725 will coordinate the collection of in-situ phenology observations and expand existing observing networks, identify and generate satellite-derived phenological/temporal metrics and test models for describing the phenological characteristics of natural and modified ecosystems. Changes in vegetation phenology impact biodiversity, net primary productivity, species distribution, albedo, biomass and ultimately the global climate.

ANNEX 1 Conferences and workshops

Conferences

4th Annual Meeting of the European Meteorological Society, - Part and Partner: 5th Conference on Applied Climatology (ECAC) -26 – 30 September 2004, Nice, France

7th International Congress of Biometeorology ICB, September 5th - 9th 2005, Garmisch Partenkirchen, Germany

3rd HAICTA International Conference on: Information Systems in Sustainable Agriculture, Agroenvironment and Food Technology, 20 – 23 September 2006, Volos, Greece

COST 725 International Conference on: Scope and current limits of linking phenology and climatology, 10. - 12.03.2009 Geisenheim Research Centre, Germany

Workshops

Workshop of WG1, 2 and 3, Budapest, 24 – 25 October 2004
Workshop of WG1, 2 and 3, Vienna, 25 – 26 April 2005
Workshop of WG3, Dublin, 27 – 28 April 2006
ESF Phenology and Agroclimatology, Exploratory Workshop, Volos, 21 – 23 September 2006
Workshop of WG1, Huntingdon, 2 – 3 November 2006
Workshop of WG2, Vienna, 4 – 5 December 2006
Workshop of WG3, Freising, 22 – 23 January 2007
Workshop and scientific excursion, Ivalo, 6 – 10 June 2007
Workshop of WG1, Escorial, 1 – 3 October 2007
Workshop of WG2, Ljubljana, 12 – 13 November 2007
Workshop and scientific fieldtrip, Bucharest, 6 – 7 May 2008
Workshop of WG1, Rome, 6 – 7 November 2008
Workshop of WG2, Zurich, 18 – 19 November 2008
Workshop of WG2, Vienna, 27 – 28 January 2009

ANNEX 2 COST related publications

Peer reviewed literature

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List of abbreviations and acronyms

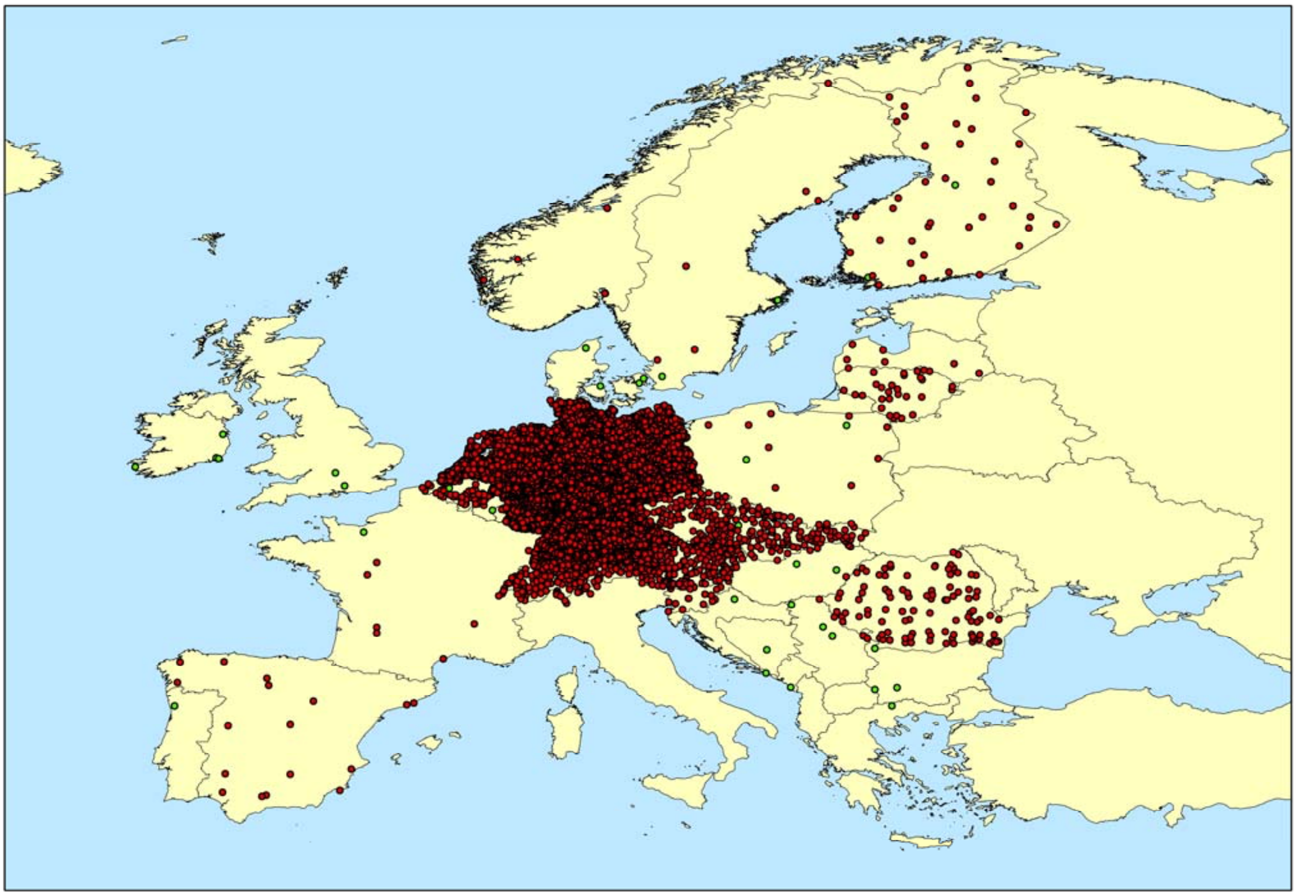
APDB	**A**ctual **P**henological **D**ata**B**ase
AR4	**A**ssessment **R**eport 4
BBA	**B**iologische **B**undes**A**nstalt für Land- und Forstwirtschaft, German Federal Biological Research Centre for Agriculture and Forestry
BBCH	**B**iologische Bundesanstalt für Land- und Forstwirtschaft, **B**undessortenamt und **CH**emische Industrie
BSA	**B**undes**S**orten**A**mt, German federal Office of Plant Varieties (BSA)
CC	**C**limate **C**hange
CEH	**C**entre for **E**cology and **H**ydrology, UK
CHMI	**C**zech **H**ydro **M**eteorological **I**nstitute
CEPDP	**C**ommon **E**uropean **P**henological **D**ata **P**latform
COST	**E**uropean **C**ooperation in the field of **S**cientific and **T**echnical Research
DOY	**D**ay **o**f **Y**ear (1-365/366)
DWD	**D**eutscher **W**etter**D**ienst, German Weather Service
EARS	**E**nvironmental **A**gency of the **R**epublic of **S**lovenia
ECAC	**E**uropean **C**onference on **A**pplied **C**limatology
ECSN	**E**uropean **C**limate **S**cientific **N**etwork
ESF	**E**uropean **S**cience **F**oundation
ESSEM	**E**arth **S**ystem **S**cience and **E**nvironmental **M**anagement
EUMETNET	**Eu**ropean **Met**eorological **Net**work
FTP	**F**ile **T**ransfer **P**rotocol
GCB	**G**lobal **C**hange **B**iology
GCOS	**G**lobal **C**limate **O**bserving **S**ystem
GEO	**G**roup on **E**arth **O**bservations
GHD	**G**rape **H**arvest **D**ays
GIS	**G**eographical **I**nformation **S**ystem
GPM	**G**lobal **P**henological **M**onitoring
GPS	**G**lobal **P**ositioning **S**ystem
IPCC	**I**ntergovernmental **P**anel on **C**limate **C**hange
IPG	**I**nternational **P**henological **G**ardens
IVA	**I**ndustrie**V**erband **A**grar, German Agrochemical Association
MC	**M**anagement **C**ommittee
MCM	**M**anagement **C**ommittee **M**eeting
MoU	**M**emorandum **o**f **U**nderstanding
NMHS	**N**ational **M**eteorological and **H**ydrological **S**ervice
NMS	**N**ational **M**eteorological **S**ervice
NOAA	**N**ational **O**ceanic and **A**tmospheric **A**dministration
NOP	**N**etwork **OP**erator
ODBC	**O**pen **D**ata**B**ase **C**onnectivity
PCA	**P**rincipal **C**omponent **A**nalysis
PEP	**P**an **E**uropean **P**henology
PEP725	**P**an **E**uropean **P**henological database
QC	**Q**uality **C**ontrol
RMIB	**R**oyal **M**eteorological **I**nstitute of **B**elgium
SQL	**S**tructured **Q**uery **L**anguage
STSM	**S**hort **T**erm **S**cientific **M**ission
TI	**T**echnical **I**nfrastructure
WCDMP	**W**orld **C**limate **D**ata and **M**onitoring **P**rogramme
WCP	**W**orld **C**limate **P**rogramme
WG	**W**orking **G**roup
WMO	**W**orld **M**eteorological **O**rganisation
ZAMG	**Z**entral**A**nstalt für **M**eteorologie und **G**eodynamik, Austrian Weather Service

Picture index

ANNEX 3

Final report from WG 2 of COST 725

Evolution of a database for European phenological data



Phenological stations (●) and International Phenological Gardens (●) included in the European phenological database

Eugenija Baksiene, Johannes Behrendt, Agrita Briede, Isabelle Chuine, Claudio Defila, Alison Donnelly, Bogo Habič, Katarzyna Jatczak, Elisabeth Koch, Ola Langvall, Wolfgang Lipa (Chairperson, WG 2), Viera Jakubíková, Finn Måge, Detlef Meier, Sara Mulder, Jiří Nekovář, Øyvind Nordli, Danuta Romanovskaja, Bernard Seguin, Andreja Sušnik, Susanne Zach-Hermann, Kirsten Zimmermann (Vice-chairperson, WG 2), Ana Žust

Abstract

Alison Donnelly

The main objective of COST 725 was to establish a European reference data set of phenological observations in addition to providing standardised protocols for making observations and handling data. The specific tasks of Working Group 2 were to create a list of plants, provide a standardised coding system for the phases to be monitored and to establish a database with appropriate quality control procedures. The aim was to achieve standardised techniques for collecting, storing and analysing phenological records for the whole of Europe to ensure compatibility between countries and phases. This is the first time coordination and standardisation of phenological data on a European scale has been attempted.

The first task was to collect information from participating countries on their phenological networks and data handling procedures. In order to carry out this task, a questionnaire was circulated which requested information on how data was collected and stored and whether or not quality control procedures were in place. Analysis of the results revealed that quality control checks ranged from a visual check of the data to the use of more sophisticated statistical techniques which automatically flagged suspicious data. Some countries did not perform any quality control of the data. Therefore, it was concluded that there was no standard protocol for quality control of phenological data in Europe. Evidently, this would have implications for the ability to make meaningful comparisons between countries.

It was necessary to identify and agree upon a standard list of plants and phases to be held in the database. This was an arduous task but following lengthy discussions consensus was reached. It was decided to adopt the BBCH coding scale for identification of phenophases which would allow, for the first time, direct comparison across species and countries throughout Europe. This coding system was build into the database templates. It was agreed to maintain the database at ZAMG who had the capacity and expertise to carry out this task. Data would be regularly updated and quality controlled. Access to the database is through a web-interface and is restricted to countries that provided data. Participants are requested to abide by certain rules set out in a policy document which basically prohibits exploitation of the data for commercial use.

The establishment of a database for European phenological data has been carried out successfully within the timeframe of the COST action. However, the continued use of this database in future is essential to maintain a standard system of phenological data handling across Europe. Therefore, it is proposed to secure funding through various international funding bodies for this purpose. It is proposed that the database will evolve in future through the establishment of the Pan European Phenology database (PEP725). This initiative will build on the COST 725 database and ensure its survival into the future.

Contents

1. Introduction and objectives

Elisabeth Koch, Wolfgang Lipa, Susanne Zach-Hermann

COST action 725, 'Establishing a European Phenological Data Platform for Climatological Applications' was established in October 2003 and working group 2 (WG 2) was formed the following year in October 2004 at the kick-off meeting in Budapest, Hungary.

Plant development is primarily under genetic control however, environmental conditions, in particular weather, have a strong influence on the timing of developmental stages. The main environmental factors affecting phenological development are temperature, precipitation and photoperiod. Recent research into global warming has sparked renewed interest in the examination of long-term instrumental and proxy indicators of climate change. Phenological records are one of the most valuable data sets with the ability to demonstrate the impact of climate change and climate variability on the development of both plants and animals at a global, regional and local scale. Due to the complexity of environmental systems it is important to identify suitable indicators capable of demonstrating change in environmental condition. Consequently, long-term records of plant phenology have demonstrated their value in climate change research.

The **main objective** of COST action 725 was to establish a European **reference data set** of phenological observations that could be used to demonstrate climate change impacts on the environment. **Secondary objectives** included were in relation to the standardisation of procedures for phenological data handling, as follows:

- standard definitions of both species and phases,
- standard protocols for monitoring, collecting and quality control procedures for data,
- standard platform for archiving and dissiminating data,
- standard mapping, statistical and presentation methods for phenological information,
- increase awareness of the relationship between climate and phenology.
- According to the COST 725 Memorandum of Understanding the main responsibilities of Working Group 2 were to:
- establish and maintain a European phenological database,
- determine a list of the most common plants and phases ,
- apply a uniform coding system for phenological phases – the BBCH scale (Meier, 1997),
- collect and apply - national experience relating to quality control of data to the database,
- build a flagging information system for identification of possible errors and outliers,
- make recommendations for monitoring and collecting procedures.

The following guidelines were designed to provide phenological networks with information on best practice for data management from both a national and a European perspective. At present, most phenological networks have their own specific management procedures. These procedures are not standardised across the European continent, for example there is no standard methodology adopted for phenological recording.

The MCM agreed with the decision to apply the BBCH scale (Meier, 1997) to all national phenological networks across Europe. The first attempts to standardise the different national phase descriptions were made by Bruns and Vliet v. (2003).

The main aims of a **national** phenological network are, to monitor the chosen species, to manage the output data, to quality control and archive this data and to make the data available to the wider community.

From a **European perspective** the main goals of a data platform are, to identify and monitor the most common plants and growing stages in Europe. Seven groups of plants were identified for inclusion in the database, as follows:

- wild plants,
- fruit trees,
- winter cereals,
- maize,
- meadow plants,
- northern plants,
- southern plants.

The most important issues were:

- to collect the national data with standardised interfaces,

- to put the data into a database and grant access to COST members,
- to define a standard set of data quality control procedures.

2. World Meteorological Organisation guidelines

Elisabeth Koch, Ekko Bruns, Frank M. Chmielewski, Claudio Defila, Wolfgang Lipa, Annette Menzel

WMO Guide to plant phenological observations - principles for observing

http://www.omm.urv.cat/documentation.html

Phenological observations do not require the use of costly equipment, as the "instrument" for monitoring environmental condition is the plant itself. Essential materials for the observer are the observation form, the observation guidelines and binoculars for large trees. Specific stages of plant-growth whose start date can be related to **a specific day** are observed. It is not sufficient to record phases using terminology such as "during the first few days of April".

The most important precondition to obtain homogenous comparable data is an **accurate definition of phases**. Furthermore, observations of the different phases of **perennial plants**[4] i.e. plants that have a lifetime of more than one year such as native and forest trees, shrubs and fruit trees are made on **an** individual plant. Extreme development that is very early or very late in a particular season in comparison to other individuals is often associated with a particular site. Attention should therefore be paid to making sure that the location of the plant to be observed is representative of the observation area. The observer should carry out the observations on the **same** plant for **as many years as possible**. **Herbaceous plants**[5] are generally observed on an annual basis at the same site, for example, meadow foxtail is commonly seen in the same meadow and mugwort along the same farm track. This means that the phenological phase in question should have occurred in several plants at this site. Observations of **crops** are usually carried out at the first cultivated field and all phenological phases during the course of a year reported for this field. It may be important to record additional information for cultivated plants. As for example, the timing of some phenological events may be influenced by changes in varieties of crop species or by watering regimes particularly in regions where rainfall variability is of concern (see metadata).

The frequency of observation depends on growth stage and on weather conditions. Thus, for example, in spring in the mid- and high-latitudes it may be necessary to make daily observations while during summer and fall (autumn) bi-weekly visits are usually sufficient.

Finally, it is more valuable to have fewer, but more reliable data, from a limited number of plants than to have a wide range of unreliable records.

Which plants?

The selection of plants to be observed depends on the aim of the phenological network (for agricultural use, human health – pollen warning, climate change monitoring, education, public information biodiversity, etc.) and on the vegetation zone (mainly related to climate). It is therefore impossible to find plants which can be observed in all climatic regions of the globe and are suitable for all purposes. But it is strongly advised to include at least some plants of the GPM and/or European backbone program (Bruns and Vliet v., 2003) in order to facilitate international network linkages.

The following **basic rules** should be applied when establishing a generic nationwide network with volunteer observers who have a limited botanical knowledge:

1. the **plants** should be **well known** and thus easily identified/recognized,
2. they should have a **broad distribution** in the region,
3. the program should contain some plants the **phases** of which should **span the whole vegetation cycle** of one year e.g. leaf unfolding, may shoot, flowering, fruit ripening, autumn/fall coloration and leaf fall.

Which phases?

In order to gain comparable phenological data it is necessary to accurately define the phases which are to be observed. The use of the extended BBCH scale (Meier, 1997) is recommended. The Zadok et al. (1974) cereal code is a system designed to give a uniform coding of phenologically similar growth stages of all

[4] perennial plants live for more than two years
[5] a plant lacking a woody stem is called herbaceous

mono[6]- and dicotyledonous[7] plant species. It is a general scale that can be applied to those plants for which no special scale is available. For the description of the **main (longer-lasting)** phenological development stages, called **principal growth stages,** clear and easily recognized external morphological characteristics are used. The **secondary growth stages** define **a shorter time period in development**.

The principal growth stages do not need to proceed in the ascending order of the table but can proceed in parallel, for example, flowering stage BBCH6 can occur before leaf development BBCH1 as it does in some fruit trees or, due to the variation between different plant species, certain stages may be omitted.

The secondary growth stages define exact points of time or steps in the plant development. They are also coded with the digits 0 to 9. The numbers 0 to 8 correspond to the respective ordinal numbers or percentage values, 0 defines the beginning, and 9 the end of the principal growth stage (e.g. BBCH60 is the beginning of flowering, BBCH69 the end of flowering). The combination of the numbers of the principal growth stage and the secondary stage results in a two digit code.

In general it is easier to observe the beginning of a phase, i.e. the secondary growth stages 0 or 1. Therefore many NMSs have chosen this growth stage for many of their observations, especially for phases at the beginning of the growing season. 50% or BBCHx5 is also often used. e.g. BBCH95 (9 being the principal growth stage for senescence, the beginning of dormancy, and the secondary growth stage 5 shows that 50% of the leaves have fallen).

Where?

The site of the plant to be observed should be typical for the observation area. Sites which are known to have climatic extremes should be avoided, or where deviations from characteristic conditions can be expected due to their topography (e.g., southern slopes speed up the plant development in early spring on the other hand frost hollows may hamper growth).

The area to be observed is generally determined by the observer. It is rare for all plants/agricultural crops of the program to exist in a small space but an area within a 1.5 – 2 km radius of the observer's base (home or workplace) is usually sufficient. Longer distances can be covered, whereby the limit should be approximately 5 km from the base point.

The "mean" geographical observation site and a "reference height" to which the data refer to must be defined for each observation area. This can be done with the help of the observer using an exact map or other means (e.g. GPS) to determine the geographical coordinates and height above sea level. The observation locations should not deviate by more than 50 m above or below this reference height.

When, how often?

The frequency of observations depends on the season and plant variety. In temperate zones during the main vegetation period, when temperatures are favorable, plants may develop relatively quickly making it necessary to carry out **daily** observations in order to obtain the exact date of a defined phase; time spans like mid- May are not sufficiently specific. For determining slower processes (such as fruit ripening) **two to three visits per week** are usually adequate.

Light and visibility (especially fog, low sun elevation, and general brightness) exert an influence on the sensitivity of the human eye to color. Therefore uniform conditions are desirable. For example, the colour of leaves is best determined when the sun is high and behind the observer (best time for this is early afternoon). This time of the day also helps to eliminate the possibility that phases might have been "missed" during previous observations (blossoms of different species often do not open until late morning).

Data transmission guidelines

The traditional observation sheet containing all plants and phases in the phenological network which is usually sent once a year to the observer is being progressively replaced by on-line databanks. But it is still of use for the observers to have a printed list with all plants and phases when visiting the sites. Having a printed version of the observation manual should provide clear rules for the observer. Pictures and graphs help to illustrate phenolog-

[6] monocotyledonous plants (have one cotyledon per seed; there are about 50.000 species of monocotyledonous plants including the grasses (as for instance rye, corn, wheat) and lilies, bananas and orchids). A cotyledon is the first leaf or the first pair of leaves (dicotyledonous plants) developed by the embryo of a seed plant or of some lower plants as e.g. ferns

[7] dicotyledonous plants have two cotyledon per seed; the dicotyledonous plants contain nearly 200.000 species from tiny herbs to great trees

ical phases and trends. As it is unavoidable that some changes in recording will occur in the course of time, a folder or something similar, with exchangeable pages, may be used as is done by the German and Austrian NMS.

Data documentation – metadata

A third of the ten GCOS Climate monitoring principles emphasizes the importance and necessity of metadata: "The details and history of local conditions, instruments, operating procedures, data processing algorithms and other factors pertinent to interpreting data (i.e. metadata) should be documented and treated with the same care as the data themselves" (http://gosic.org/GCOS/GCOS_climate_monitoring_principles.htm).

This principle has also be applied to phenology. Metadata includes administrative information such as the observers name, data inventories (what data are stored where), station description (local environment, aspect, soil type, etc.) and history, data set documentation, application/change of observation guidelines. The metadata inform the user which phenological data (plants, varieties, phases) are available, which observing rules are applied, and where the stations are located; they help to detect breaks in time series and thus make the observations comparable with each other.

3. Brief history of data control procedures

3.1 National reports

Austria

Wolfgang Lipa, Susanne Zach-Hermann, Zentralanstalt für Meteorologie und Geodynamik (ZAMG)

Phenological information has been collected and recorded in manuscript form for many years and has been stored in paper archives at ZAMG. Since the second quarter of the 20th century (about 1928) standardised paper forms have been sent to all observers to enter the dates of phenological observations for one month or for one year. These forms are returned to ZAMG by post and all observed dates are subsequently entered into the national phenological database. Every observer is registered by a special code (station identification number according to geographical coordinates).

Historical data from the paper archive are also entered into the database. The digital database was established in 1986. Data back to the 1970's have already been entered.

As the data is being entered an automatic data control process takes place. The maximum and minimum values of the date for each species and phase are stored. If a specific date lies outside this range a warning is displayed to encourage the person entering the data to check the date again. If the date is confirmed the new value is accepted as a new extreme value.

In July 2006 a new phenological web portal was presented

http://zacost.zamg.ac.at/phaeno_portal/home.html. Entering data online is now possible. A user registration is required by everyone who wants to supply data. The data user may also gain access to the following:

- interactive maps for each phase and each year for the whole of Austria,
- diagrams for each station and phase for all observed years,
- diagrams of deviations from the mean values of each phase for the whole of Austria,

diagrams of the most common plants and phases for the current year for Vienna.

Germany

Kirsten Zimmermann, Johannes Behrendt, Detlef Meier, Deutscher Wetterdienst (DWD)

The Deutscher Wetterdienst maintains at present a basic phenological network comprising around 1400 stations. The observations are transmitted once a year in a report sheet (yearly reporters). The department Technical Infrastructure (TI) collects all report sheets and after a visual check the data are stored as sequential ASCII files. These files build up the **A**ctual **P**henological **D**ata**B**ase (**APDB).** Since 2007 these archive files were transferred to the climate database system MIRAKEL.

During the operational handling of phenological data each year a gross error check for all actual data is performed. Since 2003 an additional spatial quality control has been applied. The data get two quality bytes, one after the gross error check and one after the spatial quality control. Data marked as suspicious by the gross error check are excluded from the spatial quality control.

The flagged data are corrected by manual inspection.

Gross error check

- **check whether a certain phase occurred within an allowed period.** This check is designed to exclude data which are obviously incorrect from further checks,
- **check for the right order of the phases**. The data flagged by check 1 are ignored. If the order of the phases of a plant is not correct the data are flagged as suspicious,
- **check for the differences between two consecutive phases.** The data flagged by check 1 and 2 are ignored. The differences between the consecutive phases of one plant for all stations are sorted by length. From the median these differences are inspected in both directions. If the difference between two consecutive differences of this sorted series is longer than 21 days, all associated phases are marked as suspicious,
- **check for the distribution of the phases.** All observations of a certain stage of all stations are sorted by date. From the median of these data the programme inspects in both directions. If the difference between two consecutive non suspicious data of this sorted series is longer than 21 days all earlier or later data are marked as incorrect. Due to frost periods this is not performed for blossoming of hazel and snow drop,
- **repetition of check 2 and 3 without the data marked as incorrect by check 1 and 4.** So the number of suspicious data can be reduced.

Spatial quality control

- the observation area is divided into overlapping circles with identical radii. The radius is calculated taking into account, that at least eight stations have to be situated in each circle,
- the stations, which are located in a circle, are determined. These stations are regarded as data representative of the circle,
- for each station in a circle an interpolated date is computed by a linear interpolation scheme like:

  interpolated date = C1 + C2 * elevation + C3 * latitude + C4 * longitude

  The coefficients C1 to C4 were found individually for each circle by minimising the residuals between the fitted data and the observed data,
- for each station in the circle the differences between observed and computed dates and a mean residual for each circle is calculated. If the difference is greater than the minimum of three times the mean residual and 20 days, the observed date is flagged to be incorrect.

Norway

Øyvind Nordli, Finn Måge, Norwegian Meteorological Institute

Statistical test

In Norway there is no regular, national data control of phenological data. However, when data was delivered to the COST database in February 2006, the series (spring phenophases) were checked against temperature using regression analyses. The dates of phenophase occurrences correlated well with temperature. Therefore a limit test of the residuals was an effective tool for detecting errors. Some errors were found which resulted mainly from incorrect data entry. The data came from four sites:

the fruit gardens at Ås and Njøs and the two IPGs at Fana and Kvithamar.

At Ås fruit gardens similar tests have been performed but on an irregular basis.

Biological check

Regular biological checks have been performed locally at each IPG and fruit garden.

The differences between the time of occurrences for the phenophases have been checked:

- the sequence of one plant,
- different plants in the same garden,
- the same plant in different fields (Njøs),
- different fruit cultivars within the same species (Ås).

Errors were corrected where possible by manual inspection or incorrect data were deleted from the files.

Slovakia

Viera Jakubíková, Slovak Hydrometeorological Institute Bratislava

First visual control of the actual data report

Quick control of rough errors such as incorrect year, month, species, phenophase, missing data etc. These corrections are performed after checking the data with the observer.

Procedure for entering the data

This is performed by the special software program developed for the data entering protocol. The program enables selective entering of the data according to the plant and corresponding phenological phases. The software program contains control mechanisms for eliminating errors due to incorrect coding of plants or due to incorrect date formatting.

The **quality control** of phenological data consists of three basic steps, which identify and mark extreme (suspicious or incorrect) data.

- Step 1: A check of the succession of phenological phases with flagging of incorrect data.
- Step 2: A check of the timing of the phenological phase with flagging of extreme data.
- Step 3: A check of the duration of interphase intervals following a given time span with flagging of extreme data.

Data marked by the first step are not included in the subsequent check. Extreme data identified in steps 2 and 3 are judged according to the frequency of occurrence. If the data is outside the range of extremes for more than 10% of the stations it is included in the analysis.Rare extremes will be excluded from any subsequent checks.

Slovenia

Ana Žust, Andreja Sušnik, Environmental Agency of the Republic of Slovenia (EARS)

Characteristics of data quality check procedures in Slovenia

Phenological data have been systematically collected in Slovenia since 1951 by establishing a phenological network coordinated by the agrometeorological service in the frame of the National Meteorological Service, now referred to as the Environmental Agency of the Republic of Slovenia (EARS). The data for the period 1951 to 1980 are mostly kept in classical archives (phenological books) whereas, more recent data are deposited in an electronic archive. Data quality control (QC) is a part of the phenological data management system. This system tracks the data from the first recording of each phenological phase made by the observer until the data are finally deposited in the archive (Figure 4). The final data are extracted from the archive and disseminated to the end user.

In the early phase of phenological data collection data QC procedures were predominantly based on a visual check of data entries in monthly paper reports.

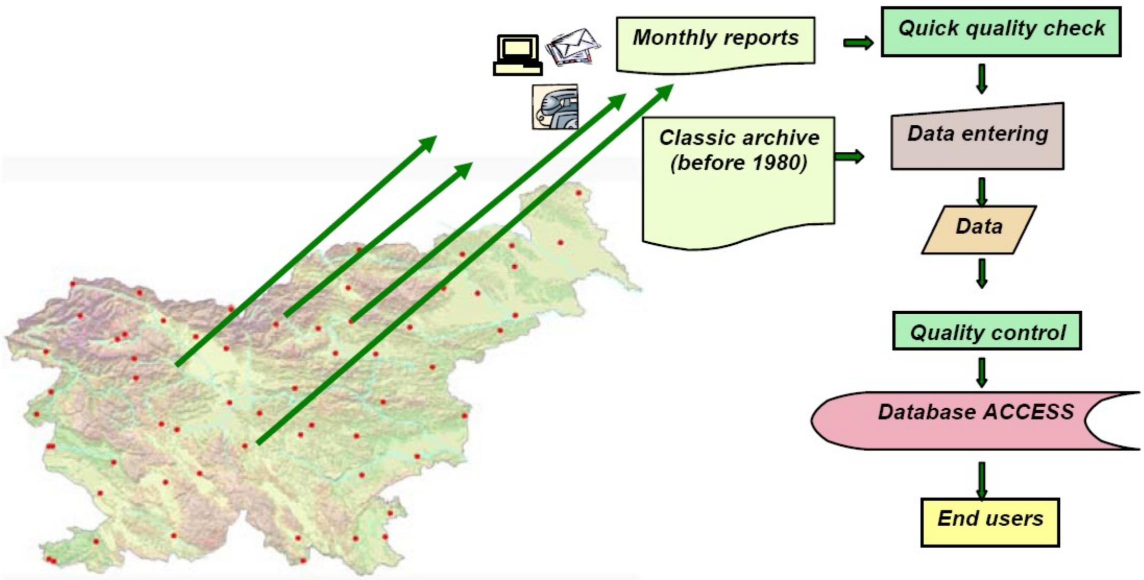


Figure 17: Phenological data flow in Slovenia.

This procedure continues to be followed at present in Slovenia. The weighting of the reliability of the data is based on the knowledge and experience gained of phenology over more than 50 years of national phenological network management and maintenance. After 1980 computer technology enabled fast detection of phenological deviations and simultaneous comparison with meteorological data stored in the same EARS database. Gradually additional automatic procedure started to develop, with combined approaches including both phenologist experiences and modern systematic data quality protocols. With further advances in computer technology in the 1990's several QC tools could be run simultaneously. But the importance of visual inspection of the data still remains a crucial part of pheno data processing.

Data QC procedures in Slovenia consists of several steps. The first step is **visual control of the actual monthly data reports.** The aim of such a quick control check is to identify data which is obviously suspicious such as incorrect year, incorrect month, incorrect phenophase, missing data etc. The corrections are performed after consultation with the observers. **Data entry** is performed through the software program. It enables data entry according to the selected plant and to corresponding phenological phases. The program contains several control mechanisms for eliminating errors due to incorrect coding of stations, plants (varieties) and phenological phases or errors due to incorrect date formatting. Errors due to skipping, duplicating or omitting the phenological phases are eliminated through simultaneous graphic checks of the time series. Following the introducion of this program the number of suspicious data due to incorrect entry decreased significantly. The next step was a **logical data control procedure** which aimed to check the correct sequence of the phenological phases. Suspicious data are initially checked in the original data reports and in communication with the observers. Unambiguous errors due to mixed sequence or due to incorrect data entry are corrected in the original reports and put in the data records. If this is not the case suspicious data are omitted. **A statistical control** system checks the data with regard to statistical evaluation of the long-term average, minimum and maximum values and standard deviation. The aim is to check the extreme values (outliers) based on standard deviation criterion (>=3σ). The reliability of the outliers is checked separately based on **bioclimatological analysis.** The extreme value of a phenological phase might be due to summer drought, extremely early or late spring, plant disease etc. The decline is weighted also by checking the record in the agrometeorological reports or meteorological annuals. The declined values are **c**ompared **spatially** with data values recorded from phenological stations with similar geographical and climatological characteristics. In addition, the extreme data which passed the control procedures are deposited in the phenological archive which is coordinated by the Environmental Agency of the Republic of Slovenia.

The outlook for future data QC in Slovenia

Experience in data QC procedures was gained over a period spanning more than 50 years in phenological network maintenance. It showed that efficient data QC should go hand in hand with the experience of phenologists and phenological observers. The weak points of data QC still remain in missing data and gaps in time series and insufficient spatial data coverage. Spatial comparison of the data is an obligatory basic approach for weighting the reliability of the data. Furthermore, relations with different environmental data should be incorporated into the quality checking procedures. Recent data QC procedures enable us to track errors and any quality control procedures used in the European phenological data platform will enable improvements of the process at the national scale.

Switzerland

Claudio Defila, MeteoSwiss

Phenological observations are not quantitative measures. The word "observations" implies some subjectivity. The recording of phenological phases, such as leaf unfolding, flowering, fruit ripening, leaf colouring and leaf fall, can differ from person to person. The choice of a precise date for phenophase completion is therefore sometimes difficult. In order to minimize the amount of subjectivity, it is important that the same person performs the observations for as many years as possible. With some experience, it should be possible to keep the determination error of the phenophase occurrence date in spring and summer in the region of +/- 2 days. When considering fruit ripening and leaf colouring, the situation is much more complicated. Even if good pictures are available in the book „*Pflanzen im Wandel der Jahreszeiten*" (Brügger and Vassella, 2003), some uncertainty remains for the observer. For leaf fall, leaves already lying on the ground have also to be taken into account for the estimation of the 50% limit. The lower quality of phenological data in autumn is probably a reason why there was, up to now, no satisfactory modeling of the phenological autumn. Fruit ripening data have never been scientifically studied in Switzerland, although autumn data have been carefully determined. In Switzerland, the density of the observation network is a great advantage and reduces the importance of isolated errors. Trend analysis based on Swiss phenological data (Defila and Clot, 2001; Defila and Clot, 2005) and European-wide studies with different data quality show very similar results (Menzel et al., 2006).

The following errors can be found in phenological data sets:

- recording errors by the observer on the original sheet (e.g. typing in the wrong column of the table: this occurs frequently with hazel flowering and leaf unfolding, because, contrary to many other plants, hazel flowering occurs before leaf unfolding. The incorrect month is also frequently recorded, e.g. April instead of May,
- errors can occur when the data are manually typed into the databank. This type of error is rare in Switzerland, because all data are entered twice by two different people,
- subjective errors due to the observer. As mentioned before, this type of error is rare,
- some species can be misidentify by the general public, e.g. broad-leaved linden vs. small-leaved linden.

In addition to the errors mentioned above, heterogeneity in the data series can arise when the observations are no longer possible at the same site, for example because of buildings or clearings. Observations of single individual plants are even more problematic, because trees are often felled and bushes cut. This requires a new plant or a new site to be found. Every individual plant has its own genetic and age-related behavior. A change in the site of observation can also result in a shift in the data series, because the date of occurrence of phenological phases is very much influenced by the microclimate. For these reasons, as far as possible, an entire population or field should be observed. Moreover, a change in the observer may add to the heterogeneity because of the subjectivity inherent in the observation.

The following methods are used for quality control of phenological data in Switzerland:

- obvious errors can be corrected during typing of the data into the database, e.g. flowering of coltsfoot in summer or in case of incorrect succession of the phases (hazel leaf unfolding before flowering, or chestnut flowering before leaf unfolding, etc…),
- outliers can be identified with the help of a phenological calendar (Defila, 1992). When a date is unusual, compared to the statistical distribution of the phenophase at this location, then this date has to be checked,
- graphic comparison of series of the same phenological phase in neighboring stations can also help in identifying errors,
- similarly, several successive phases in the same station can be compared. This is however only possible when the phases are strictly consecutive,
- the annual succession in time of the different phenological phases is already problematic. Phenophases that occur very early in the year (e.g. hazel flowering in January) are followed by phases that occur in spring (e.g. larch leaf unfolding, dandelion flowering). Subsequently, the summer phases occur, such as linden or grape flowering; and at the end, in autumn, leaf coloring and leaf fall mark the end of the vegetation period. However, inside these categories, the succession in time of the different phenophases is not constant. Does horse-chestnut leaf unfolding occur before cherry flowering? Does broad-leaved linden flower before grapevine? Or does horse-chestnut leaf coloring occur before beech? These small differences in succession can vary from site to site and also form year to year at the same location,
- a spatial control of the phenological data is also quite difficult in Switzerland. There are differences between the Northern and Southern slopes of the Alps. Homogenous climatic areas are very small in Switzerland and therefore there are not enough observation stations left to perform efficient statistical analysis,
- in an alpine country such as Switzerland, a control of the data relative to the altitude cannot be avoided. The observation station at the lowest altitude is located in Ticino at 200m a.s.l. and the highest in Engadin at 1800m a.s.l. For an automated plausibility test, five altitudinal divisions were defined (lower than 500m, 500 to 799m, 800 to 999m, 1000 to 1199m and higher than 1200m). Limits for the earliest and latest possible dates were set for every phenophase and altitude. Dates that lie outside these limits are deleted. This is called a plausibility test because data that are possibly incorrect can be further investigated at the next stage in the quality control procedure. The setting up of the limits and the control of the data is time consuming and requires a lot of experience in phenology. With such a method, questionable data can now be tested. In doubtful cases, the observer's decision has to be maintained. When the right date can be clearly reconstructed, with the help of several methods (series, incorrect typing), data can be corrected. If this is not possible, questionable data have to be deleted. Such clarification requires a large scientific knowledge; otherwise there is a risk of deleting extreme data, which would have been the case in 2003 (Defila, 2004),
- at MeteoSwiss, only the test for the limits for every phenophase and altitude has been automated. However, the detailed control of questionable data is performed by hand which requires many hours work.

As this short overview has shown, quality control of phenological data is a very complex task, possibly more demanding than the verification of climate data. The range of possible occurrence dates for every single phenophase can be as large as three months, as is the case for hazel flowering, which can occur as early as December, or as late as March.

3.2 *Results of the questionnaire on national data quality control procedures*

Ana Žust, Andreja Sušnik, Environmental Agency of the Republic of Slovenia (EARS)

The background

The main objective of COST 725 was to establish a European reference phenological data set (Common European Phenological Data Platform, CEPDP) that could be used for climatological purposes, especially climate monitoring and detection of climate change. The origin of the idea was in inconsistencies in phenological data collection, data control and the structure of databases in different countries in Europe.

The first step in establishing the phenological data platform was the assessments of data in the participating countries of COST 725. Initially, data related issues included concerns relating to different spatial coverage, availability of data, time periods, different observation programs and hetrogeneity and different methods of quality control.

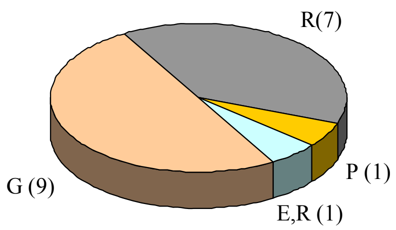
At the 5th MC meeting in April 2006, in Dublin, members agreed to complete a questionnaire survey on phenological databases. The aim of the questionnaire was to assemble information on national data quality checks and to provide information on data quality assurance of the CEPDP. During several discussions the importance of a standard format for further observations and quality assurance for a European scale was stressed.

A questionnaire was sent to the representatives of COST 725 member countries. Answers from 15 countries were obtained: Austria, France, Germany, Ireland, Slovakia, Finland, Slovenia, Poland, Romania (two institutions), Norway, Latvia, Spain, Lithuania, Luxembourg and UK.

The questionnaire had a total of 18 questions (Appendix I). The first five questions were related to data ownership, the remaining questions were related to the notification of procedures incorporated into the national quality control procedures. Some of the main findings arising from the answers are summarised below, Q1– ownership of the data, Q2 – national estimates of phenological data quality, Q3– national state of data quality check, and Q4 –quality check procedure.

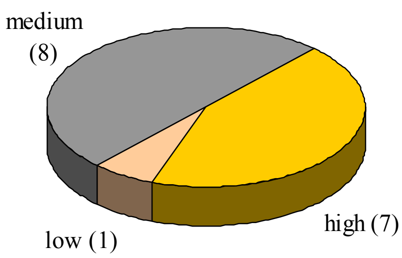
Outcomes of the questionnaire

Q1.Ownership of phenological data



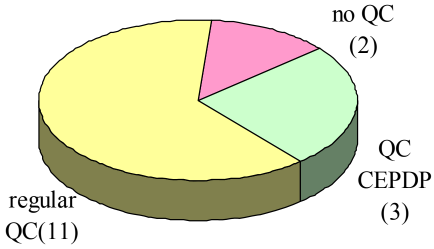
Ownership of the data includes responsibility for its management, quality control and maintenance. The state of the ownership reflected the institutional diversity of the national phenological networks. Most of the countries reported that the phenological networks belong to governmental institutions (G), NMHS, research (R) and educational (E) institutions. Only one country reported private (P) ownership of the phenological data.

Q2. National estimates of the quality of phenological data



Most countries estimated high and medium quality for the national data which are included in the European Phenological Data Platform. Phenological data were considered to be of high quality if they are fit for their intended use in operations, decision-making and planning.

Q3. National state of data quality checks

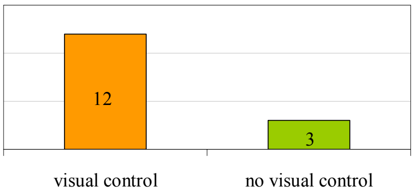


Most countries performed regular quality checks on their phenological databases, only very few countries needed to be prompted to perform QC by CEPDP. Two countries did not perform quality checks at all. Less than half of the countries used software programs to perform quality control checks.

Q4. Reported quality checking precedures

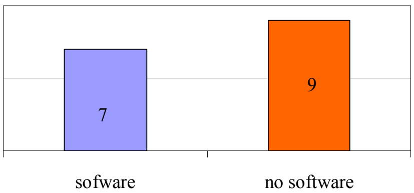
The main quality checks reported were visually based, elimination of data entry errors, logical data control, statistical data control, determination and treatment of the outliers and spatial data control.

Visual data checks



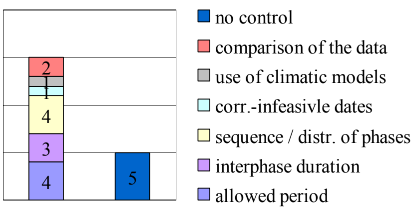
The majority of countries reported performing visual checks to identify suspicious data. Effective communication with the phenological observers was the most common and effective mechanism to clarify suspicious data and to improve data quality in general.

Elimination of data entering errors



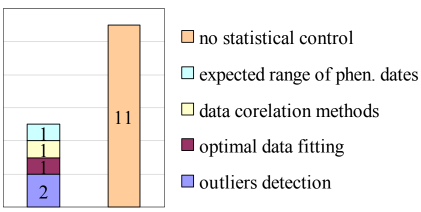
Data entry is prone to errors both simple and complex. Several countries reported the use of software programs as an efficient step for eliminating this type of error. In addition, one country reported significantly less errors following application of the software program.

Logical data control



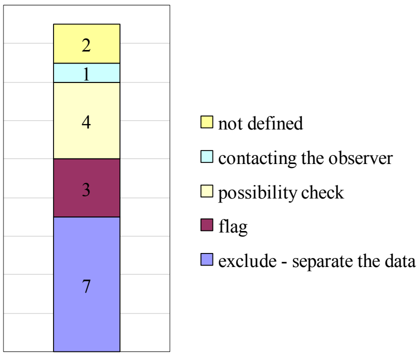
More than half of the countries reported performing a logical data control check, based on different approaches. The most commonly used methods were by checking the permitted period for the phenological phase appearance (constrains), interphase duration and correct sequence of the phenological phases. The use of climatic models, correction of non-feasible dates and comparison of the data were also reported as methods of logical data control.

Statistical data control - tracing of extreme values – outliers



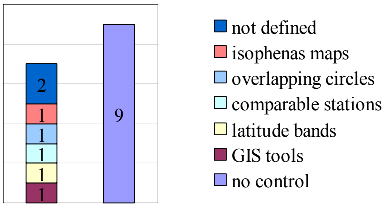
Statistical methods were not often reported as being used to check data quality. Two countries defined it as a method to detect outliers. Other methods reported in the frame of statistical control were data correlation methods and optimal data fitting and proofing of the expected range of phenological phases.

Determination and treatment of outliers



The detection of outliers can provide one of the most useful tests for detecting possible errors. But not all outliers are errors. Countries reported different approaches to treating outliers. The most frequent was the exclusion of suspicious outliers. Two countries reported that they introduced flagging system to indicate suspicious values. Three countries performed an additional check of the suspicious values. One country reported to clarify the suspicious data by contacting the observers.

Spatial quality control - comparison and correlation of data in space



Only seven countries reported spatial weighting for data QC. The most simple approach was based on the comparison of the suspicious data with the data recorded at comparable stations. Other methods reported were the use of spatial coherence (isophenas maps), latitude bands and overlapping circles. Only one country reported the use of GIS tools. Two countries have not defined a method.

Conclusions

The survey presents the first general overview of the phenological data checking procedures, however, only half of the countries in the action were represented in the survey. It was evident that data in different countries are dispersed throughout different institutions. Most of the data belonged to governmental, research and educational institutions. Quality checks were performed regularly, but no standard protocol was adopted. Therefore different approaches could not be easily merged into one common protocol for data quality control. Furthermore, quality checking methods were often combined with each other. Nevertheless, most of the countries reported visual or logical steps for quality checking. Few countries reported statistical or spatial approaches. A flagging system was not a commonly accepted system to identify suspicious data. Spatial control ranged from the simple comparison of the data to the more elaborate methods of evaluating the data in space. A few countries were in the process of developing separate steps of QC procedures.

Analysis of the results revealed that a lot of attention was paid to checking individual data and therefore the need for a very experienced phenologist and standardised observing procedures are required.

4. <u>Establishing a European phenological database</u>

Wolfgang Lipa, Susanne Zach-Hermann, Zentralanstalt für Meteorologie und Geodynamik

The need to establish a European database was identified by the Management Committee (MC). Each MC member was requested to sign a national data support declaration as well as the data policy document. In addition, members were asked to comply with quality control procedures relating to data management.

ZAMG became chair of Working Group 2 and agreed to provide the following:

- complete hardware and software with WEB access,
- human resources for development, analysis and maintenance of the entire database.

The first issue was to establish a list of selected plants and phases. This work took 7 months and was finished during the workshop in Vienna in April 2005. In a lengthy discussion attended by WG1 and WG 2 the list of plants was approved and the first **milestone** was reached.

In order to establish the database (Appendix II) a unique BBCH coding scale was built and standard templates for both data and metadata management were developed. The second **milestone** was reached in June 2005.

Data collection proved to be a challenging task and remains incomplete. Some of the issues encountered related to (a) the templates not being used correctly, (b) some data being rejected and (c) other data requiring formatting. The number of data providers increased progressively but **8** members did not supply any data. In summer 2006 a weekly email reminder was circulated, but with no success, and consequently the data remains to be collected. Therefore, access to the database is restricted to suppliers of correctly formatted data. Nevertheless it was considered sufficient to have data from **19** members and so **milestone 3** was reached in December 2006.

In order to enable data access by other data users an ftp account was established in June 2006 which was in part fulfilment of **milestone 4**. One year later, an interface based on a PhP/Myadmin tool was installed and demonstrated at the 7th WG 2 meeting in Lubljana. However, the users were not familiar with the interface and therefore failed to adopt it due to the high degree of technical expertise required for its use. Therefore, it was considered necessary to develop a more user-friendly system. This task was to be performed by Bogo Habic in Lubljana who took advantage of an STSM in Vienna in March 2008 to gain expertise in the use of open-source software.

In order to enable quality control procedures to be established, Andreja Susnik and Ana Zust distributed a questionnaire to all COST 725 members in summer 2006 to collect information relating to current quality control procedures. The results (see chapter 3) proved useful in establishing a data quality control process for the database. During nearly all MC and WG 2 meetings, a discussion on data quality control took place. The final meeting to confirm the quality control procedures took place in Vienna in December 2006. The outcomes of that meeting are as follows,

- each national data provider should apply the proposed data quality control procedures,
- as regards flagging of errors and/or outliers a second “single time series” flag and a third “spatial” flag were developed. Both flags will be used in the database by using the database’s quality control procedures,
- handling of events which take place in the previous year (negative values for DOY, for instance for DOY 360 in the previous year → DOY will become -6 in the actual year),
- events which take place twice in one year should be stored in a second table (flowering of some fruit trees, snow drops,..).

Following adoption of the above points the data table structure was redesigned in March 2007 and **milestone 5 was reached**.

4.1 Data and metadata

Wolfgang Lipa, Susanne Zach-Hermann

The database consists of the phenological data table and several metadata tables describing information related to the stations, the phase codes of plants and information about the flagging system (Figure 6).

The data table is as follows:

- the Pheno_data table relates specifically to the phenological observation data.

The metadata tables are as follows:

- the **pheno_stat** table contains information relating to the physical location of the station in question,
- the **country_code** table relates specifically to the countryname and id,
- the **phase_code** table contains informations on the plants and phases.

The flagging metadata tables are as follows:

- the **flag_national** table relates to the national flagging system, which is specific for each country,the **flag_serial** table relates to outliers in a time series,
- the **flag_spatial** table relates to outliers on a spatial scale.

4.2 Regular update of the database with current data

Kirsten Zimmermann, Deutscher Wetterdienst (DWD)

Storage of the current national phenological data

The time periods and meta-data relating to the phenological data sets are stored in the databank at ZAMG in Vienna. Based on this data inventory data update should be performed on an annual basis. The data are initially verified according to the following procedure:

- identification of format: Do they correspond to the standard format? If not, the data provider is requested to reformat the data to comply with the standard format,
- identification of stations: Do all stations fullfill the metadata requirements? If not, the data provider is requested to supply the correct information.

Updating meta-data is very important as the phenological data on their own are useless without the necessary information relating to the station.

After this pre-checking process, a quality control check should be performed according to the standards being developed for the European phenological database. This process is essential to ensure the sustainability of the database in future.

Preparation of the data at national level

The initial request was that all participants would supply their national phenological data together with the corresponding meta-data on an annual basis. However, this goal was not achieved, partly because of the extra workload associate with the conversion from a national format to the new European format proposed.

4.3 Requirements for the data quality control procedures

Kirsten Zimmermann, Deutscher Wetterdienst (DWD)

The functioning of the European phenological database is dependant upon stringent quality control procedures for all data. These quality controls should be performed on the data on arrival at ZAMG inVienna. However, prior to the delivery of the data to the databank, quality checks are performed at a national level.

Quality control of the data should be performed automatically as it is considered too time consuming to perform visual checks on each time series for each plant and phase. Therefore a quality control procedure should be developed which includes the following steps:

- firstly, national thresholds need to be established. One way in which this may be achieved is to sort each time series according to the day of year on which the observation occured. The lower limit could be set at the fifth lowest value –30 days and the upper limit at the fifth highest value +30 days. Data outside of this range should be flagged as outliers,
- secondly, outliers need to be checked. This may be performed by calculating the arithmetic mean and the standard deviation (sigma) of each time series. If the absolute difference between the arithmetic mean and the observed value is greater than or equal to 3*sigma, then the data will be relayed to the data provider who is requested to check or verify the extreme value,
- finally, the sequences of the phases need to be checked. This task can be performed by comparing the sequence of the BBCH-code with the sequence of the date value of the time series.

The quality control procedure is shown in Figure 18 and the values of the flags are presented in Appendix IV.

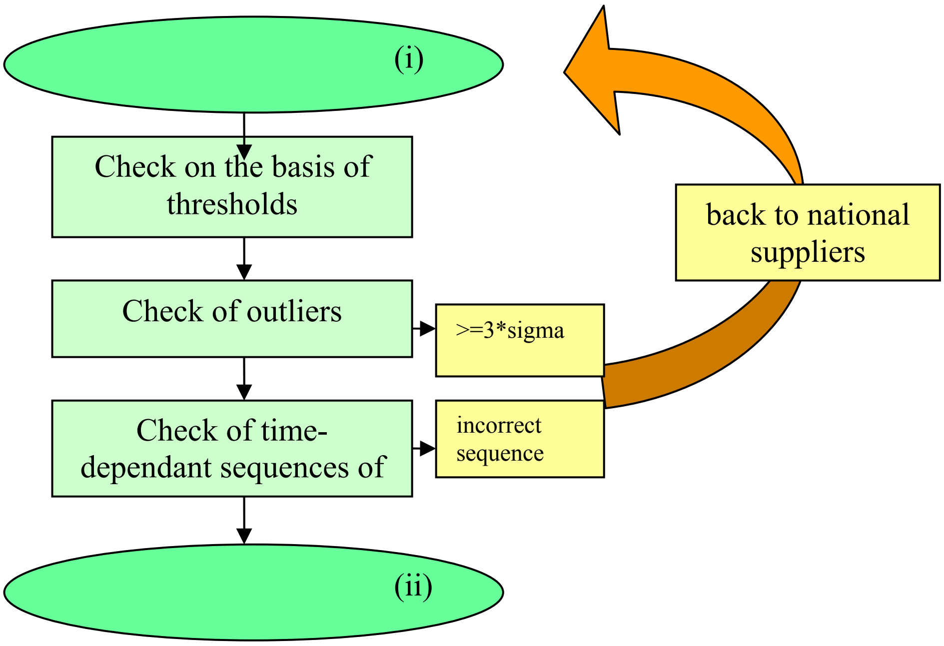


Figure 18: Quality control procedure for the European phenological database

4.4 Results, conclusions and lessons learned during COST 725 WG 2

Austria
Susanne Zach-Hermann, Zentralanstalt für Meteorologie und Geodynamik (ZAMG)

Phenology in Austria has a very long tradition as is evident from the brief history in chapter 2. Therefore and as a result of our experience with database management ZAMG supported COST action 725 with expertise, hardware and software. The European phenological database was established in Vienna. It is maintained at ZAMG Vienna and should also be maintained there after the end of COST 725.

During COST 725 we learned a lot about the challenges of integrating different ideas of the member states concerning data collection. There were very diverse opinions about the plants and growing phases to collect. Finally after long discussions we prepared a template including representative plants and corresponding growth codes.

We also learned a lot about the problems of collecting data from different members. First it was challenging to locate and/or make contact with the data owners from each country. In spite of having guidelines for data format and distributing a template for data collection a lot of data providers were not able to deliver data in the requested format. If there were only small changes to be made, we carried out this task and entered the data into the database. If the data format was completely incorrect we returned the data to the providers for reformatting. A small number of countries did not provide data.

Some internal problems with the database arose. The database was first established on a Linux PC system with very little working space. Performing some manipulations within the database or making data updates overstrained the system and created very large temporary files, which made efficient working impossible. Therefore the whole database was transferred to our large SYBASE database system (“SYBKLIM”). However, access to SYBKLIM is restricted to ZAMG-personnel. Therefore an FTP account was established to download data (FTP server www.zamg.ac.at). The contents of all data tables could be found in ASCII files and also in compressed (zipped) files. Another option was to get the ASCII data files by email, which was not recommended because of the large data volume that can cause problems at the mail server of the participants. A disadvantage of these two methods is the large ASCII-files as mentioned above. The files have to be updated after each small change. Hence the data was shifted to a MySql-Server to allow external access to the phenological database via ODBC to all COST 725 members. But it appeared that several users are not familiar with SQL, so we had to search for another solution, which seems to be a web portal for uploading and downloading data in a very easy and user friendly way.

France

Bernard Seguin, Mission 'Changement climatique et effet de serre' (MICCES), INRA Unité Agroclim

Isabelle Chuine, Fonctionnement des Écosystèmes, Centre d'Ecologie Fonctionnelle et Evolutive

The French contribution to COST 725 has been of medium significance, mainly because the investment of French science in phenology has been very limited during the last 30 years. Making in-situ observations, especially on a long term basis, has been largely ignored and considered less prestigious than numerical modelling or genomics. As reported in the historical section, it is only in the last decade that phenology is making a come back.

It has not been possible for us to play a significant role in the building and exploitation of the European data-base, which is the major achievement of COST 725

- firstly, because the available existing database (Phenoclim) was very recent (it began in 2003), so that the main partners were not in favour of early dissemination, and was also limited to fruit trees and vine. This was a different field from most of the participating countries who were more interested in natural vegetation. However, a sample of seven representative sites has been added in order to complete the database. In addition, the contact established with Belgium has allowed for testing of a model for the flowering date for apple tree for the two countries (Legave and Oger, 2007),
- secondly, because the collection of phenological data from natural vegetation and forests, which could have significantly contributed to the COST 725 study, is only taking place now, and will not become operational for one or two years. However, at least the metada of the French phenological database should be provided before the end of the COST action.

The overall success of COST 725 has been through stimulation and for helping the 'new beginning' of phenology in France, so that the participation of Isabelle Chuine and Bernard Seguin may be considered useful for the future of phenology in Europe. Conversely, we may hope that their expertise in climatology, phenology modelling and remote sensing have been useful for the work and discussions of the COST 725 group.

Germany

Kirsten Zimmermann, Deutscher Wetterdienst (DWD)

Participation in WG 2 was of particular interest to the Deutscher Wetterdienst (DWD) asWG 2 is the designated platform for European data exchange. Phenological data and their climatological evaluation are useful for climate monitoring and research. As climate is not constrained by political borders international co-operation is essential for useful exchange of phenological data.

The DWD runs a comprehensive archive of German phenological data and is therefore able to support the European phenological database with extensive data input. In the initial stages of data acquisition there was the challenge of deciding which plants and phases should be included in the database because the opinions of the participating countries differed greatly. However, after a lot of discussion and some compromise the list of plants and phases for the database were agreed upon. The data acquisition itself was a very complex task and it took a long time to build the database. In order to ensure the sustainability of the database for future climate research projects it should be updated regularly with current phenological data and accompanying meta-information. Each participant in the COST 725 action is requested to develop a procedure which prepares the current data for operational update once a year. This procedure should follow the same rules as for the initial data delivery.

Working with members of WG 2 proved to be a very positive experience. The meetings were useful and well-organised. In addition, the WG 2 meetings afforded the opportunity to interact with other members and to discuss different scientific topics.

The COST 725 action is a milestone on the way to a European wide co-operation for the use and exchange of phenological data. But the collection and archiving of the data would not be possible without the engagement and work of the colleagues of the ZAMG in Vienna

Ireland

Alison Donnelly, School of Natural Sciences, Trinity College Dublin

The involvement of Ireland in COST 725 WG 2 proved invaluable for gaining national funding from the Environmental Protection Agency (Ireland) to establish a specialised research group to investigate the impacts of climate change on phenology and its implications for terrestrial ecosystems. Up to this time Ireland's only contribution to the phenology community was through data collected as part of the International Phenological Gardens Network. Ireland will now be in a position to establish a phenological network of its own and begin to develop a database for recordings.

Ireland's contribution to WG 2 was limited due to the lack of data being generated. However, in April 2006 the COST 725 management committee meeting was held in Dublin, which proved to be a success. Ireland has also made a small contribution to the data release policy document being led by Sara Mulder which is due for completion soon. I found working with WG 2 participants to be very supportive and motivating for research purposes and for forging collaborative links.

Latvia

Agrita Briede, Faculty of Geography and Earth, SciencesUniversity of Latvia

The phenological network in Latvia is based on volunteers, which have collected phenological data over several decades for different places without fixed station locations. An integrated phenological database was absent from Latvia up to 2003, when two BSc students developed an electronic database. Up to this point all data had been recorded on paper.

Participation in the project provided the motivation to expand the database to include different species and different phenological phases. Participation in COST 725 afforded exchange of experience with different project partners and the adaptation of various methods for the development of a phenological database in Latvia. In addition, participation in the project afforded the opportunity to use these data for climate change research.

Our knowledge in the development of a database included several aspects such as collection of metadata of the station, use of the BBCH code, data quality checking, etc.

Further experience gained included statistical analyses of the data carried out in association with all project partners for publication in a high ranking journal. The above-mentioned knowledge was enhanced by the possibility to discuss many aspects of phenological research during variouss meetings and conferences. We would like to emphasize that it was very important for Latvia to be involved in COST 725 as, only few people are involved in phenological studies in our country. In addition we have also gained some ideas for the development of a web page. The indepth discussions on historical data and phenological records were extremely valuable.

Lithuania

Danuta Romanovskaja, Eugenija Baksiene, Voke Branch of the Lithuanian Institute of Agriculture

Phenological observations have been carried out in Lithuania since 1959. The data accumulated during a 40–year period in Lithuania proved to be a valuable contribution to the European phenological database. While taking part in the COST 725 programme's WG 2 group we presented phenological data from a total of 30 stations, of which 25 stations' data covered an observation period of 20-40 years. The material contained the data of long-term phenological observations of 24 plant species (16 wild and 8 cultivated species). We expect that after the European phenological database has been set up, Lithuania's phenological data will provide additional information regarding changes in plant development in the North-Eastern European region and will be used for research purposes.

Cooperation with other countries' researchers in the WG 2 group was of great benefit to us. Firstly, we became aware of the scope of phenological observations in other European countries. As a result, we were able to put Lithuania's phenological research into a European context. Secondly, European phenological data joined the database thanks to the COST 725 programme which will encourage a wider cooperation between researchers and will enable them to initiate new scientific research. We are convinced that the phenological observations will not lose their relevance in the future. This prompted us to take measures to preserve and expand Lithuanian phenological network, whose decline has been marked during the last two decades. The activities of the WG 2 group have also encouraged us to set up a Lithuanian phenological database. Implementation of our ideas needed financial investment. The agency for international science and technology development programmes provided financial support, thanks to which we arranged expeditions designed to expand the phenological network and start developing a phenological database for Lithuania.

Poland

Katarzyna Jatczak, Institute of Meteorology and Water Management

Participation in the activities of WG 2 was a useful source of information and practical advice, which we were able to implement in colleting phenological data in Poland.

One particular example was the use of the BBCH code which was implemented to classify phenophases in Poland.

Another result was the data quality control system, based on the following steps:

a) visual checks with graphical display,

b) logical control (corrections of sequences of phenological phases),

c) statistical checks - the earliest and the latest date for phenophases from all stations (general period possible appearance of phenological phase), average duration of phenological phases, (mean value; two standard deviations),

d) data flagging program for detecting errors in data (exceeding general period of appearance of relevant phenological phase).

The majority of our activities have been concentrated recently on creating a new interactive phenological database, which permits observers to enter their phenological data on-line.

Scientific Name	English name	Event	BBCH
Corylus avellana	Hazelnut	begining of flowering	61
Tussilago farfara	Coltsfoot	begining of flowering	61
Padus avium	Hagberry	begining of flowering	61
Taraxacum officinale	Dandelion	begining of flowering	61
Betula pendula	European white birch	leaf unfolding	11
Siringa vulgaris	Lilac	begining of flowering	61
Aesculus hippocastanum	Horse chestnut	begining of flowering	61
Robinia pseudoacacia	Bastard acacia	begining of flowering	61
Tilia cordata	Littleleaf linden, small leaved lime	begining of flowering	61
Aesculus hippocastanum	Horse chestnut	first ripe fruits	81
Calluna vulgaris	Heather	begining of flowering	61
Aesculus hippocastanum	Horse chestnut	coloring of leaves	92
Betula pendula	European white birch	coloring of leaves	92
Betula pendula	European white birch	falling of leaves	95

Figure 19: BBCH-code in the Polish phenological database.

At the beginning of the phenological network, in 1951, observers submitted data on paper however, more recently transfer of data by email is more common. Due to the growing amount of pheonological stations, it was necessary to create an on-line phenological database based upon the European Phenological data platform.

Tools and technology used in the Polish Phenological Database include:

Tools

- Apache
- MySql
- GrADS

Technology

- PHP
- JavaScripts
- AJA

Slovenia

Ana Žust, Andreja Sušnik, Environmental Agency of the Republic of Slovenia (EARS)

The original aim of COST 725 defined in the European phenological database was to establish a unique and homogeneous phenological European reference data set for climatologically purposes. In spite of a long-term tradition in phenology at the European level, the implementation of the idea was not an easy task due to the fact that phenological data originate from different national phenological networks and institutions. WG 2 focused more or less on organisational and technical tasks of the establishment of the database. A list of plants and their phases was established and coded according to the BBCH scale coding system. In addition, data format for archiving and exchanging of the data was determined. One very important task was the collection of the data quality control information at the national level and the establishment of standard quality measures for the database.

The Memorandum of Understanding (MoU) outlined a preference (in the terms of references for establishing the Database) for the selection of wild plants which are better indicators of climate variables than crops and genetically modified plants. The selection of plants was discussed and agreed upon through the cooperation of the member countries. Later the list of plants broadened to include various crops.

The data collection process met with several challenges due to the difficulties associated with providing the data by the accepted deadlines. The reasons given were generally either technical (electronic format and data control) or arose at the institutional level. Unfortunately the delay in inclusion of the data hindered the work of WG 2 most seriously regarding the development of the web interface for data assessment.

In spite of clearly defined rules for making observations, phenological data are dependent, in part, on subjective assessment. Investigation of data quality checking procedures indicated that quality checks at the national level were performed regularly, but there was no standard protocol. Quality checks were found to be predominantly based on the experience and expertise in phenology. The different approaches to quality control could be easily merged into one common protocol that could be applied to the database. The only exception was the establishment of a flagging system to indicate suspicious data. The assesment of the realibility of the data will remain in the hands of the data provider who is responsible for checking the data in accordance with environmental conditions.

The acceptance of the terms of the MoU could be considered as a legal act of agreement to allocate the phenological data in the database. Nevertheless, the production of the data policy was one of the most challenging tasks. Seeking compromise led to several suggestions and discussions. The decision to allow data access for research and education among participating countries that provided data to the database was unanimous. All other use of the data was agreed to be at the discretion of the data owner.

WG 2 activities met with several challenges, most relating to various phenological traditions, ownership and views on the data policy. WG 2 successfully overcame these issues and the reference data set is now close to completion. Furthermore, discussion on the future of the database expressed the will of the countries to maintain and update the database in future.

Switzerland

Claudio Defila, MeteoSwiss

In recent years, the importance of phenology as an indicator of the influence of climate change on vegetation development was internationally recognized. A large number of scientific publications, such as the contribution in the 4th IPCC report, provided concrete evidence of the usefulness of phenology for climate research. Most of the scientific contributions in phenology are restricted to individual countries. A European databank was required for providing data evaluation at a continental scale. In that databank, data have to be of high quality, quality-controlled and comparable between countries. The COST 725 action allowed the partial achievement of this goal.

In future, the following improvements are expected:

1. Evaluation at a continental scale could only be partly realized. Consequently, phenological observations and observation programs have to be intensified throughout Europe.
2. There is no standard selection of plants being observed over the whole of Europe. Consequently, plants growing in all regions of Europe have to be selected. Some of these should be selected among the plants already observed by national phenological networks in order to benefit from the existing long-term data series. The list of plants observed by national networks should be completed.
3. The same phases are not being observed everywhere. Consequently, a selection of phenological phases should be made, for example leaf unfolding, begin of flowering, full flowering, fruit ripening, leaf coloring, leaf fall, etc.
4. Data quality differs considerably from one country to another. Consequently, it is necessary to define a data quality control system.

Conclusions:

- in order to be able to continue collecting data relating to the influence of climate change on vegetation development at a continental scale in future, phenological data should be delivered regularly to the European databank after the end of the COST 725 action. This could be acheived by establishing a contract between the different countries,
- it is very important to publish guidelines for phenological observations and quality control, including the list of plants and the description of phenophases to be observed,
- the COST 725 action facilitated the accumulation of a lot of knowledge on phenology. The continuation of the collaboration is necessary in order to benefit from the synergies. Annual meetings including scientific presentations, information exchange and working groups would be one way of maintaining contact.

5. Access to the database

Wolfgang Lipa, Susanne Zach-Hermann, Zentralanstalt für Meteorologie und Geodynamik

The European phenological database was first established on a linux pc system. After initial problems it was transferred to the Austrian national SYBASE database system with internal access only. Therefore ASCII files of the raw data were extracted from the corresponding data tables. These files were updated after the insertion of new data into the phenological data tables and were available to all participants through an FTP account (www.zamg.ac.at) with a user name and password. The information could be downloaded in ASCII formats or in compressed files.

Figure 20: EuPhenoNet environment.

Linux	Debian GNU/Linux etch 4.0
Apache	2.2.3-4+etch5
MySQL	5.0.32-7etch6
PHP	5.2.0-8+etch13

Given the constraints imposed by FTP, it was considered necessary to make the data available in a more user friendly manner through the construction of a MySQL database. In August 2007 the MySQL database was constructed. It became evident, that many users were unfamiliar with the SQL language and an alternative solution for accessing data was required. A web application was developed to gain access to the data which was composed of a user friendly web portal. This task was performed during an STSM in Vienna by Bogo Habic from Slovenia in March 2008.

Further developments were performed at the Agrometeorological Department of the Slovenian Meteorological Office as a contribution to COST 725 in November-December 2008.

The European phenological data are stored on a Microsoft MySQL server. Chart Director software was proposed for graphical visualisation of the data beacuse it was considered to be a low-cost and comprehensive tool for generating dynamic web pages including facilities for producing graphics. And finally, scripting languages used for client-side interactivity in the frame of platform are PHP and JavaScript.

5.1 EuPhenoNet- web application for European phenological database

Bogo Habič, Ana Žust, Andreja Sušnik, Environmental Agency of the Republic of Slovenia (EARS)

The MySQL database is running on a Linux server at ZAMG. Access to the EuPhenoNet contents is authorized and performed through a login page. The database administration and user authorization are performed by the database administrator (ZAMG).
EuPhenoNet - web application functionality is based on the structure of the database and further moduled in different views.

The EuPhenoNet - web application has been developed and tested at the Environmental Agency of the Republic of Slovenia in Ljubljana (EARS). For this purposes a copy of the database was installed at EARS. In Figure 20 some of the main characteristics of the working environment and tools are described.

Performance of the European phenological platform at ZAMG will follow after upgrade of the MySQL database. The existing ftp server (zacost.zamg.ac.at) is still used for data exchange.

As mentioned above, application of a two–tier architecture type (client/server) is written in PHP and JavaScript. For graphical data visualisation, ChartDirector (PHP) must be installed and is later included in scripts as library for producing chart.

The hierarhical structure of the application is presented in Figure 21 and supporting files are described in Figure 23.

A general user – interface has been further developed by introducing the possibility for users to manage data according to the scheme (Figure 22).

Phenological data in the MySQL database are organised in supporting tables. The user interface is identical in several ways with slight changes in the way that users get a quick overview of the data. The system is moduled in the following parts of the menu-bar:

Database model

Metadata

Data overview

Data stats

ZAMG - phpMyAdmin (users administration and data downloading)

The description of the contents in the menu-bar is as follows.

Database model presents the application's basic description.

Following part of EuPhenoNet presents Metadata structure of database and supporting tables contents.

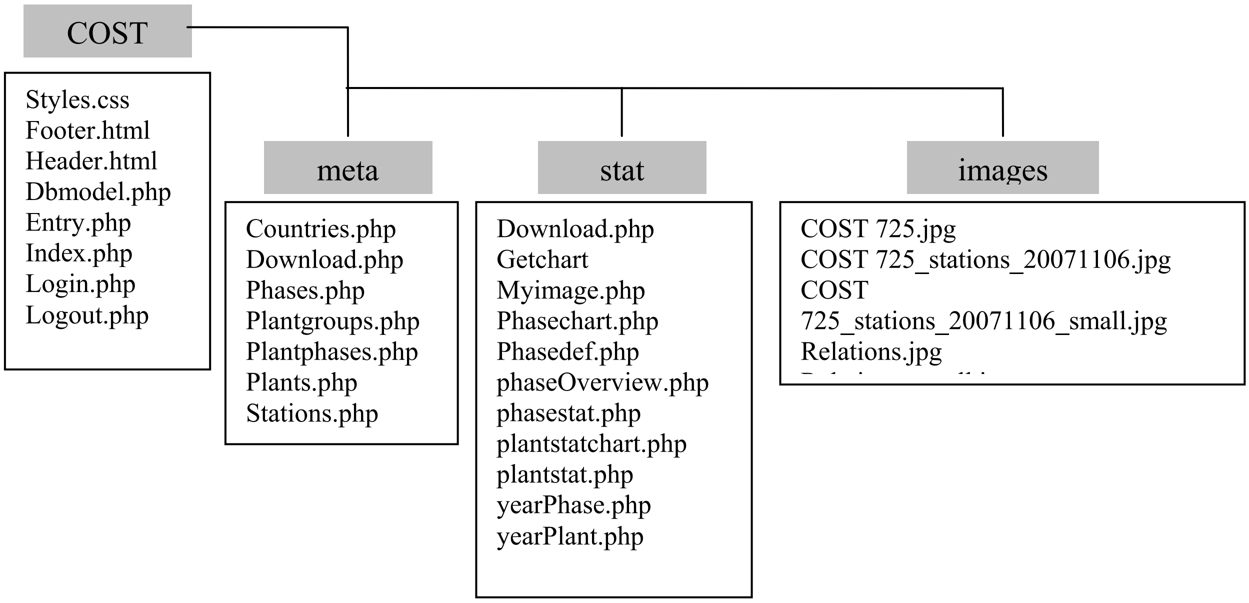


Figure 21: Structure of EuPhenoNet- web application directories.

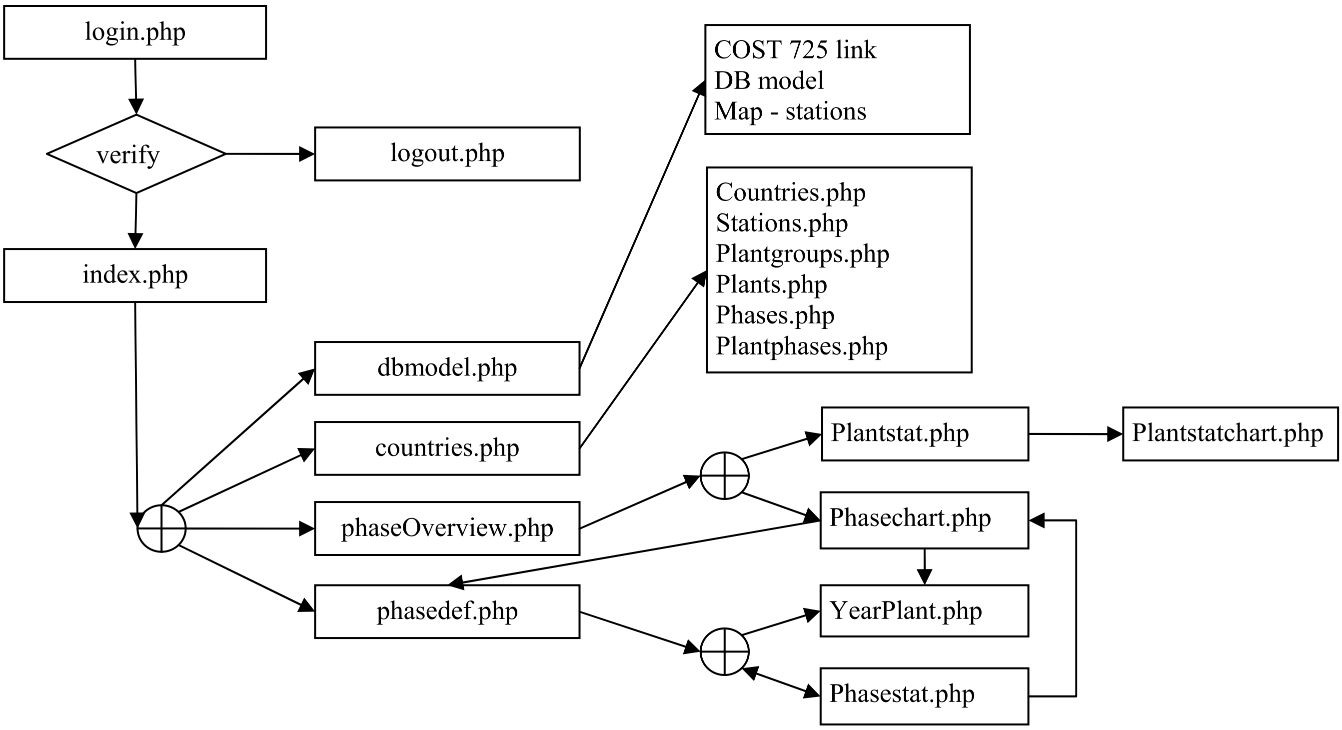


Figure 22: Procedures and links in the EuPhenoNet- web application.

Figure 23: Application's supporting files descriptions.

COST 725	
Styles.css	predefined html styles, used for web app
Footer.html	text at bottom of web contents
Header.html	text at top of web contents
Dbmodel.php	database description
Entry.php	user checking
Index.php	application's preface
Login.php	logging file
Logout.php	logging out
IMAGES	
COST 725.jpg	background picture from COST 725 official site
COST 725_stations_20071106.jpg	all stations
COST 725_stations_20071106_small.jpg	all stations (small size)
Relations.jpg	all stations
Relations_small.jpg	all stations (small size)
META	
Countries.php	list of member countries
Download.php	data downloading script
Phases.php	list of phases
Plantgroups.php	plant groups overview
Plantphases.php	list of phases for every plant
Plants.php	list of plants
Stations.php	list of stations
STAT	
Download.php	data downloading script
Getchart	chart import script (ChartDirector)
Myimage.php	image import script (ChartDirector)
Phasechart.php	phase graphical and statistical descriptive script (4 charts)
Phasedef.php	data statistics parameters
phaseOverview.php	data overview for plants and stations
phasestat.php	selected phase through selected period for selected stations
plantstatchart.php	multiple phases (country/station/plant/phases) chart
plantstat.php	selected station plants data overview
yearPlant.php	yearly plant pheno cycle

In the Data overview, users can get a quick overview of site-specific data availability over selected period (countries / stations / plants) and basic statistics for the chosen data in table formats (Figure 24). Some graphical presentation of the data is also permitted. A dynamic menu-bar enables users to download data in selected charts or in delimited text files.

Data stats serve as an input menu for parametric data search. Users have the possibility to select country(ies), station(s), plant(s), phase(es) and observed period. The output is equivalent to the data overview, as users get a chart with plotted data and some statistics for selected parameters (Figure 25).

Through link ZAMG – phpMyAdmin user is redirected to the old database access at ZAMG.

In the development of such a new system, it is important to have tight control of data quality in the database and information about data submitted by an individual data provider.

It will be important to continue to upgrade the application in a user-friendly manner in future. At present the application lacks the use of maps but Google Maps may provide a solution to this problem.

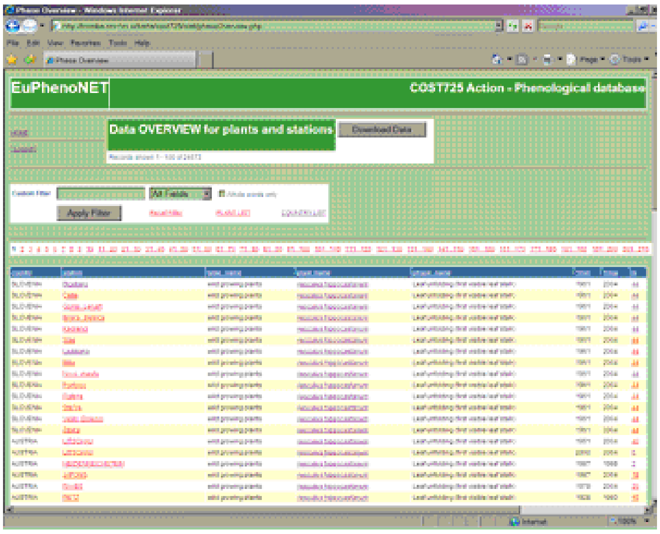


Figure 24: Data overview menu-bar.

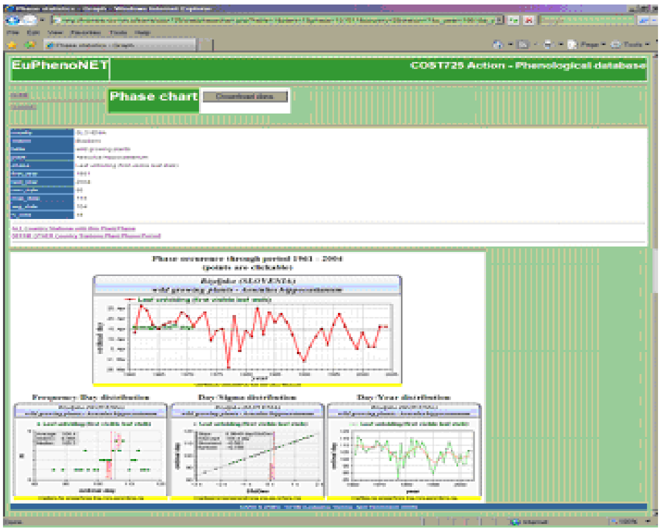


Figure 25: Plant/phase/station statistics form.

The role of the future system (application) administrator should be to control the distribution of submitted data to different categories of users, register any new user. Nevertheless, the problem of funding such a platform exists, as resources for maintaining a database are limited.

Currently the major bottleneck for a successful web application system is the low feedback from data providers. There is no doubt that it will improve, for example with renewed interest in phenological data. Special attention is to be paid to the consideration of the best possible way to disseminate phenological data to all potential end-users.

6. Data policy

Alison Donnelly, Elisabeth Koch, Ola Langvall, Sara Mulder

COST 725 data release policy

All data and information collated by COST 725 are made available online with as few restrictions as possible, on a nondiscriminatory basis. Great care is taken to avoid releasing the identity of individual observers or locations of specific observations that are deemed to be 'sensitive'. However, in cases where it is necessary to confirm an observation or data point, individual observers may be identified on the basis of an identification code linked to relevant information such as qualifications (e.g. Master Gardener) etc. This information may be released at the discretion of the particular Data Set Owner once the Database User has demonstrated compliance with the terms and conditions set out by this document. COST 725 participants should make every effort to release data in a timely fashion and pay particular attention to accurate and complete metadata.

Data

There are two types of Data Sets in the COST 725 Database:

Type I Data Sets are to be released to the *general public* according to the terms of the general data use agreement (see below) within 2 years from collection and no later than the publication of the main findings from the dataset.

Type II Data Sets are to be released to *restricted audiences* according to terms specified by the owners of the data. Type II Data Sets are considered to be *exceptional* and should be rare in occurrence. The justification for exceptions must be well documented and approved by the COST 725 office if in existence and otherwise by the data owner. Examples of Type II data restrictions may include locations of rare or *endangered species*. Researchers that make use of Type II Data Sets may be subject to additional restrictions to protect any applicable commercial or confidentiality interests.

Metadata

- metadata documenting Data Sets will be made available when, or before, the Data Set itself is released according to the terms above,
- all metadata will be publicly available regardless of any restrictions on access to the data itself,
- all metadata will follow COST 725 recommended standards and will minimally contain adequate information on proper citation, access, contact information, and discovery. Complete information including methods, structure, semantics, and quality control/assurance is expected for most Data Sets and is strongly encouraged.

COST 725 database access requirements

The access to all Data Sets available from the COST 725 database is subject to compliance with this policy document to enable Data Set Owners and the COST 725 office to *track usage*, evaluate its impact in the community, and confirm Database Users' agreement with the terms of *acceptable use*. The following information is required directly or by proxy prior to the release of any Data Set:

- Registration
    - Name
    - Affiliation
    - Email Address
    - Full Contact Information
- acceptance of the General Public Use Agreement or Restricted Data Use Agreement, as applicable,
- a Statement of Intended Use that is compliant with the above agreements. Such statements may be submitted via the data access portal interface.

Data providers wishing to impose further requirements beyond these are encouraged to include them in their Restricted Data Use Agreements accompanying the datasets.

Data use agreements

Data Sets released from the COST 725 Database will be accompanied by an agreement that specifies the conditions for data use. For Type I Data Sets, this shall be the *General Data Use Agreement*. This document outlines general rules and any conditions associated with use of the data together with the obligations of the data user. For Type II Data Sets, a *Restricted Data Use Agreement* must be provided with the Data Set that identifies the specific restrictions on the use of the data and their justification. Because these are expected to be unique to the dataset, no template is provided although in most cases the General Data Use Agreement can be modified to fit this purpose.

General data use agreement

Definitions

"(COST 725) Database" – Collection of all "Data Sets" belonging to COST 725.

"(COST 725) *Data Set*" – Digital data and its metadata submitted to the COST 725 Database by one of the COST 725 members. "*Database User*" - Individual to whom access has been granted to the COST 725 Database, including his or her immediate collaboration sphere, defined here as the institutions, partners, students and staff with whom the Database User collaborates, and with whom access must be granted, in order to fulfill the Database User's intended use of the Database."*Data Set Owner*" – Individual or institution that holds intellectual property rights to one of the COST 725 data sets. Note that this may or may not be defined as a legal copyright. "*Data Set Contact*" - Party designated in the accompanying metadata of a COST 725 Data Set as the primary contact for this particular Data Set.

"COST 725 office" - Institution providing access to the COST 725 Database.

Conditions of use

The re-use of scientific data has the potential to greatly increase communication, collaboration and synthesis within and among disciplines, and thus is fostered, supported and encouraged. Permission to use this data set is granted to the Data User free of charge subject to the following terms:

- acceptable use. Use of the COST 725 Database will be restricted to academic, research, educational, government, recreational, or other not-for-profit professional purposes. The Database User is permitted to produce and distribute derived works from this Database provided that they are released under the same license terms as those accompanying this Database. Any other uses for the Database or its derived products will require explicit permission from the Owner(s) of the Data Set(s),
- redistribution. The Database is developed for use by the Data User. The metadata and this license must accompany all copies made and be available to all users of the

Database. The Data User will not redistribute COST 725 Data Sets or part there of, beyond this collaboration sphere,

- citation. It is considered a matter of professional ethics to acknowledge the work of other scientists. Thus, the Data User will properly cite the used COST 725 Data Sets in any publications or in the metadata of any derived data products that were produced using the Database. Citation should take the following general form: -COST 725, Year of Data Publication, Name of data set, Origin of data set, Date of data download,
- notification. The Data User will notify the Data Set Contact and the COST 725 office when any derivative work or publication based on or derived from the Data Set is distributed. The Data User will provide the data contact and the COST 725 office with a digital copy of any publications resulting from use of the Data Set and will provide digital copies, or on-line access to, any derived digital products. Notification will include an explanation of how the Data Set was used to produce the derived work,
- collaboration. The Database has been released in the spirit of open scientific collaboration. Database Users are thus strongly encouraged to consider consultation, collaboration and/or co-authorship with the owner(s) of the used Data Set(s).

By accepting these conditions of use, the Database User agrees to abide by the terms of this agreement. Data Set Owner(s) and the COST 725 office shall have the right to terminate this agreement immediately by written notice upon the Data User's breach of, or non-compliance with, any of its terms. The Data User may be held responsible for any misuse that is caused or encouraged by the Data User's failure to abide by the terms of this agreement.

Disclaimer

While every effort has been made to ensure the accuracy of the data and the documentation contained in the COST 725 database, complete accuracy of data and metadata cannot be guaranteed. All data and metadata are made available on an "as is" basis without warranties of any kind. Under no circumstances will the database owner (COST 725) accept liability for any damage, either direct or indirect, that may result from the use of this database or interpretation of the data contained therein.

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8. Appendix

Appendix I. *Questionnaire on national data quality control procedures*

COST 725: Establishing of European Phenological Database

Questionaire on national data quality control procedures

The primary goal of the questionnaire is to assemble information on national QC procedures and to provide the documentation on data quality assurance of the European Database.

The realization of the Questionnaire is based on the decision accepted at Dublin meeting, April 26-27, 2006.

1.Who is the owner of the phenological data which you submit in the EPN? (indicate also the name) _______________________________________	*Governmental institution*	
	Research institution	
	Private	
	Other	
2. How do you estimate the quality level of the phenological data you submit to the EPN?	*Low*	
	Medium	
	High	
3. Have the data passed the QC procedure?	*Yes*	
	No	
4. Which person was in charge for the data QC procedure (indicate also the institution, department)?	__________________________	
5. Do you perform QC of the phenological data for the purpose of EPN or is it already established protocol in your phenological database?	*Only for EPN*	
	Common protocol	
6. Do you have any software program to alleviate the procedure QC?	*Yes*	
	No	
7. Please describe the main steps of QC procedure or provide a flow chart (on separate sheet)!		
8. Do you perform visual data control before data recording?	Yes	
	No	
9. If yes, describe the procedure briefly on separate sheet!		
10. How do you keep of data entering errors?		
11. Do you perform logical data control?	*Yes*	
	No	
12. If yes, describe what are the measures of logical data control: (Interphase duration, correct sequence of phenological phases, allowed period, …etc.)		
13. Do you perform statistical data control?	*Yes*	
	No	
14. If yes, what are the measures of statistical data control (data modelling methods, distribution of phases, 3б, expected range of dates….etc.)		
15. How do you determine the outliers (extreme) values?		
16. How do you deal with the extreme values?	Exclude	

	Flag	
	Other check *(describe briefly)*	
17. Do you perform spatial data quality control?	*Yes*	
	No	
18. If yes, describe what are the measures of spatial data control procedure?	*GIS Tools*	
	Other (describe briefly)	

Appendix II. *Template: selection list of plants*

phase_id	phase_text
101010	*Aesculus hippocastanum*: First leaves seperated (mouse ear)
101011	*Aesculus hippocastanum*: Leaf unfolding(first visible leaf stalk)
101060	*Aesculus hippocastanum*: First flowers open
101065	*Aesculus hippocastanum*: Full flowering
101086	*Aesculus hippocastanum*: First ripe fruits
101094	*Aesculus hippocastanum*: Autumnal colouring of leaves (50%)
101097	*Aesculus hippocastanum*: End of autumnal leaf fall (95% fallen)
102010	*Alnus glutinosa*: First leaves seperated (mouse ear)
102011	*Alnus glutinosa*: Leaf unfolding(first visible leaf stalk)
102060	*Alnus glutinosa*: Beginning of flowering / first pollen spread
103060	*Alopecurus pratensis*: Beginning of flowering / first pollen spread
104060	*Ambrosia artemisiifolia*: Beginning of flowering / first pollen spread
105060	*Artemisia vulgaris*: Beginning of flowering / first pollen spread
106010	*Betula pendula* (B. verrucosa, B. alba): First leaves seperated (mouse ear)
106011	*Betula pendula* (B. verrucosa, B. alba): Leaf unfolding(first visible leaf stalk)
106060	*Betula pendula* (B. verrucosa, B. alba): Beginning of flowering / first pollen spread
106094	*Betula pendula* (B. verrucosa, B. alba): Autumnal colouring of leaves (50%)
106097	*Betula pendula* (B. verrucosa, B. alba): End of autumnal leaf fall (95% fallen)
107010	*Corylus avellana*: First leaves seperated (mouse ear)
107011	*Corylus avellana*: Leaf unfolding(first visible leaf stalk)
107060	*Corylus avellana*: Beginning of flowering / first pollen spread
107086	*Corylus avellana*: First fruits fall naturally
107094	*Corylus avellana*: Beginning of flowering / first pollen spread
107097	*Corylus avellana*: First fruits fall naturally
108010	*Fagus sylvatica*: First leaves seperated (mouse ear)
108011	*Fagus sylvatica*: Leaf unfolding(first visible leaf stalk)
108086	*Fagus sylvatica*: First fruits fall naturally
108094	*Fagus sylvatica*: Autumnal colouring of leaves (50%)
108097	*Fagus sylvatica*: End of autumnal leaf fall (95% fallen)
109060	*Forsythia suspensa* : First flowers open
110010	*Picea abie*s (P.excelsa): First Spring sprouting
110060	*Picea abies* (P.excelsa): Beginning of flowering / first pollen spread
111010	*Quercus robur* (Q.peduncula): First leaves seperated (mouse ear)
111011	*Quercus ro*bur (Q.peduncula): Leaf unfolding(first visible leaf stalk)
111086	*Quercus robur* (Q.peduncula): First fruits fall naturally
111094	*Quercus robur* (Q.peduncula): Autumnal colouring of leaves (50%)
111095	*Quercus robur* (Q.peduncula): 50 % autumnal leaf fall
112010	*Sambucus nigra*: First leaves separated
112060	*Sambucus nigra*: First flowers open
112065	*Sambucus nigra*: Full flowering
112086	*Sambucus nigra*: First ripe fruits
112097	*Sambucus nigra*: End of autumnal leaf fall (95% fallen)
113060	*Dactylis glomerata*: Beginning of flowering / first pollen spread
114060	*Tussilago farfara*: First flowers open
115010	*Acer platanoides*: First leaves seperated (mouse ear)
115011	*Acer platanoides*: Leaf unfolding(first visible leaf stalk)
115060	*Acer platanoides*: First flowers open
115086	*Acer platanoides*: First ripe fruits
115097	*Acer platanoides*: End of autumnal leaf fall (95% fallen)

116010	*Acer pseudoplatanus*: First leaves seperated (mouse ear)
116011	*Acer pseudoplatanus*: Leaf unfolding(first visible leaf stalk)
116060	*Acer pseudoplatanus*: First flowers open
116086	*Acer pseudoplatanus*: First ripe fruits
116097	*Acer pseudoplatanus*: End of autumnal leaf fall (95% fallen)
117010	*Alnus incana*: First leaves seperated (mouse ear)
117011	*Alnus incana*: Leaf unfolding(first visible leaf stalk)
117060	*Alnus incana*: Beginning of flowering / first pollen spread
118060	*Anemone nemorosa*: First flowers open
119010	*Betula pubescens*: First leaves seperated (mouse ear)
119011	*Betula pubescens*: Leaf unfolding(first visible leaf stalk)
119060	*Betula pubescens*: First flowers open
119094	*Betula pubescens*: Autumnal colouring of leaves (50%)
119097	*Betula pubescens*: End of autumnal leaf fall (95% fallen)
120010	*Fraxinus excelsior*: First leaves seperated (mouse ear)
120011	*Fraxinus excelsior*: Leaf unfolding(first visible leaf stalk)
120060	*Fraxinus excelsior*: First flowers open
120094	*Fraxinus excelsior*: Autumnal colouring of leaves (50%)
120097	*Fraxinus excelsior*: End of autumnal leaf fall (95% fallen)
121060	*Galanthus nivalis*: First flowers open
122010	*Larix decidua*: First needle unfolding
122094	*Larix decidua*: Autumnal colouring of leaves (50%)
123060	*Prunus spinosa*: First flowers open
123065	*Prunus spinosa*: Full flowering
124060	*Robinia pseudoacacia*: First flowers open
124065	*Robinia pseudoacacia*: Full flowering
125060	*Salix caprea*: First flowers open
126010	*Sorbus aucuparia*: First leaves seperated (mouse ear)
126011	*Sorbus aucuparia*: Leaf unfolding(first visible leaf stalk)
126060	*Sorbus aucuparia*: First flowers open
126065	*Sorbus aucuparia*: Full flowering
126086	*Sorbus aucuparia*: First ripe fruits
126094	*Sorbus aucuparia*: Autumnal colouring of leaves (50%)
126097	*Sorbus aucuparia*: End of autumnal leaf fall (95% fallen)
127010	*Syringa vulgaris*: First leaves seperated (mouse ear)
127011	*Syringa vulgaris*: Leaf unfolding(first visible leaf stalk)
127060	*Syringa vulgaris*: First flowers open
127065	*Syringa vulgaris*: Full flowering
127086	*Syringa vulgaris*: First ripe fruits
127097	*Syringa vulgaris*: End of autumnal leaf fall (95% fallen)
128060	*Taraxacum officinale*: First flowers open
129010	*Tilia cordata*: First leaves seperated (mouse ear)
129011	*Tilia cordata*: Leaf unfolding(first visible leaf stalk)
129060	*Tilia cordata*: First flowers open
129094	*Tilia cordata*: Autumnal colouring of leaves (50%)
129097	*Tilia cordata*: End of autumnal leaf fall (95% fallen)
220060	*Malus x domestica* (early cultivar by name): First flowers open
220065	*Malus x domestica* (early cultivar by name): Full flowering
220069	*Malus x domestica* (early cultivar by name): End of flowering
220087	*Malus x domestica* (early cultivar by name): Fruits ripe for picking
220095	*Malus x domestica* (early cultivar by name): 50 % autumnal leaf fall
221060	*Malus x domestica* (late cultivar by name): First flowers open
221065	*Malus x domestica* (late cultivar by name): Full flowering

221069	*Malus x domestica* (late cultivar by name): End of flowering
221087	*Malus x domestica* (late cultivar by name): Fruits ripe for picking
221095	*Malus x domestica* (late cultivar by name): 50 % autumnal leaf fall
222060	*Prunus avium* (Cerasus avium) (early cultivar by name): First flowers open
222065	*Prunus avium* (Cerasus avium) (early cultivar by name): Full flowering
222069	*Prunus avium* (Cerasus avium) (early cultivar by name): End of flowering
222087	*Prunus avium* (Cerasus avium) (early cultivar by name): Fruits ripe for picking
222094	*Prunus avium* (Cerasus avium) (early cultivar by name): Autumnal colouring of leaves (50%)
223060	*Prunus avium* (Cerasus avium) (late cultivar by name): First flowers open
223065	*Prunus avium* (Cerasus avium) (late cultivar by name): Full flowering
223069	*Prunus avium* (Cerasus avium) (late cultivar by name): End of flowering
223087	*Prunus avium* (Cerasus avium) (late cultivar by name): Fruits ripe for picking
223094	*Prunus avium* (Cerasus avium) (late cultivar by name): Autumnal colouring of leaves (50%)
224007	*Vitis vinifera*: Beginning of sprouting
224011	*Vitis vinifera*: Leaf unfolding
224060	*Vitis vinifera*: First flowers open
224065	*Vitis vinifera*: Full flowering
224069	*Vitis vinifera*: End of flowering
224081	*Vitis vinifera*: Beginning of ripening
224094	*Vitis vinifera*: Autumnal colouring of leaves (50%)
224097	*Vitis vinifera*: End of autumnal leaf fall (95% fallen)
225010	*Prunus domestica* (early cultivar by name): First leaves seperated (mouse ear)
225011	*Prunus domestica* (early cultivar by name): Leaf unfolding(first visible leaf stalk)
225060	*Prunus domestica* (early cultivar by name): First flowers open
225065	*Prunus domestica* (early cultivar by name): Full flowering
225069	*Prunus domestica* (early cultivar by name): End of flowering
225087	*Prunus domestica* (early cultivar by name): Fruits ripe for picking
226010	*Prunus domestica* (late cultivar by name): First leaves seperated (mouse ear)
226011	*Prunus domestica* (late cultivar by name): Leaf unfolding(first visible leaf stalk)
226060	*Prunus domestica* (late cultivar by name): First flowers open
226065	*Prunus domestica* (late cultivar by name): Full flowering
226069	*Prunus domestica* (late cultivar by name): End of flowering
226087	*Prunus domestica* (late cultivar by name): Fruits ripe for picking
227010	*Pyrus communis* (early cultivar by name): First leaves seperated (mouse ear)
227011	*Pyrus communis* (early cultivar by name): Leaf unfolding(first visible leaf stalk)
227060	*Pyrus communis* (early cultivar by name): First flowers open
227065	*Pyrus communis* (early cultivar by name): Full flowering
227069	*Pyrus communis* (early cultivar by name): End of flowering
227087	*Pyrus communis* (early cultivar by name): Fruits ripe for picking
228010	*Pyrus communis* (late cultivar by name): First leaves seperated (mouse ear)
228011	*Pyrus communis* (late cultivar by name): Leaf unfolding(first visible leaf stalk)
228060	*Pyrus communis* (late cultivar by name): First flowers open
228065	*Pyrus communis* (late cultivar by name): Full flowering
228069	*Pyrus communis* (late cultivar by name): End of flowering
228087	*Pyrus communis* (late cultivar by name): Fruits ripe for picking
229011	*Ribes rubrum*: Leaf unfolding
229060	*Ribes rubrum*: First flowers open
229065	*Ribes rubrum*: Full flowering
229087	*Ribes rubrum*: Fruits ripe for picking
330000	*Hordeum vulgare* (spring): Sowing/drilling
330010	*Hordeum vulgare* (spring): Emergence

330031	*Hordeum vulgare* (spring): First node just above surface detectable
330051	*Hordeum vulgare* (spring): Beginning of heading: tip of inflorescence emerged
330055	*Hordeum vulgare* (spring): Middle of heading: half of inflorescence emerged
330059	*Hordeum vulgare* (spring): End of heading: inflorescence fully emerged
330085	*Hordeum vulgare* (spring): Soft dough
330100	*Hordeum vulgare* (spring): Harvest
331000	*Hordeum vulgare* (winter): Sowing/drilling
331010	*Hordeum vulgare* (winter): Emergence
331031	*Hordeum vulgare* (winter): First node just above surface detectable
331051	*Hordeum vulgare* (winter): Beginning of heading: tip of inflorescence emerged
331055	*Hordeum vulgare* (winter): Middle of heading: half of inflorescence emerged
331059	*Hordeum vulgare* (winter): End of heading: inflorescence fully emerged
331085	*Hordeum vulgare* (winter): Soft dough
331100	*Hordeum vulgare* (winter): Harvest
332000	*Secale cereale* (winter) Sowing/drilling
332010	*Secale cereale* (winter): Emergence
332055	*Secale cereale* (winter): Middle of heading: half of inflorescence emerged
332060	*Secale cereale* (winter): First flowers open
332061	*Secale cereale* (winter): Sowing/drilling
332085	*Secale cereale* (winter): Soft dough/Yellow (wax) ripe
332100	*Secale cereale* (winter): Harvest
333000	*Triticum aestivum* (winter): Sowing/drilling
333010	*Triticum aestivum* (winter): Emergence
333031	*Triticum aestivum* (winter): Beginning of stem elongation/shooting
333051	*Triticum aestivum* (winter): Beginning of heading: tip of inflorescence emerged
333055	*Triticum aestivum* (winter): Middle of heading: half of inflorescence emerged
333059	*Triticum aestivum* (winter): End of heading: inflorescence fully emerged
333085	*Triticum aestivum* (winter): Soft dough/Yellow (wax) ripe
333100	*Triticum aestivum* (winter): Harvest
334000	*Avena sativa* (spring, cultivar by name): Sowing/drilling
334010	*Avena sativa* (spring, cultivar by name): Emergence
334055	*Avena sativa* (spring, cultivar by name): Middle of heading: half of inflorescence emerged
334085	*Avena sativa* (spring, cultivar by name): Soft dough/Yellow (wax) ripe
334100	*Avena sativa* (spring, cultivar by name): Harvest
335000	*Avena sativa* (winter, cultivar by name): Sowing/drilling
335010	*Avena sativa* (winter, cultivar by name): Emergence
335055	*Avena sativa* (winter, cultivar by name): Middle of heading: half of inflorescence emerged
335085	*Avena sativa* (winter, cultivar by name): Soft dough/Yellow (wax) ripe
335100	*Avena sativa* (winter, cultivar by name): Harvest
336000	*Beta vulgaris* : Sowing/drilling
336010	*Beta vulgaris* : Cotyledons horizontally unfolded – first leaf visible (pin-head size)
336100	*Beta vulgaris* : Harvest
337000	*Helianthus annuus* : Sowing/drilling
337010	*Helianthus annuus* : Emergence
337051	*Helianthus annuus* : First flower buds visible
337061	*Helianthus annuus* : First flowering
337100	*Helianthus annuus* : Harvest
338010	*Solanum tuberosum* (early, cultivar by name): Sprouting
338060	*Solanum tuberosum* (early, cultivar by name): First flowers open
338100	*Solanum tuberosum* (early, cultivar by name): Harvest
338110	*Solanum tuberosum* (early, cultivar by name): Planting
339010	*Solanum tuberosum* (late, cultivar by name): Sprouting
339060	*Solanum tuberosum* (late, cultivar by name): First flowers open

339100	*Solanum tuberosum* (late, cultivar by name): Harvest
339110	*Solanum tuberosum* (late, cultivar by name): Planting
340000	*Secale cereale* (spring): Sowing/drilling
340010	*Secale cereale* (spring): Emergence
340055	*Secale cereale* (spring): Middle of heading: half of inflorescence emerged
340060	*Secale cereale* (spring): First flowers open
340085	*Secale cereale* (spring): Soft dough/Yellow (wax) ripe
340100	*Secale cereale* (spring): Harvest
440000	*Zea mays*: Sowing/drilling
440010	*Zea mays*: Emergence
440031	*Zea mays*: First node just above surface detectable
440051	*Zea mays*: Beginning of tassel emergence: tassle detectable at top of stem
440055	*Zea mays*: Middle of tassel emergence: middle of tassel begins to seperate
440059	*Zea mays*: End of tassel emergence: tassel fully emerged and separated
440061	*Zea mays*: Flowering 10% (male)
440075	*Zea mays*: Beginning of milk ripeness
440085	*Zea mays*: Dough stage
440110	*Zea mays*: Harvest: silage
440120	*Zea mays*: Harvest: corn-cob-mix
440130	*Zea mays*: Harvest: corn
550101	Meadow: 25% green in Spring
550102	Meadow: 1. cut for silage winning
550103	Meadow: 1. cut for hay winning
660060	*Calluna vulgaris*: First flowers open
661060	*Cornus mas*: First flowers open
662010	*Epilobium angustifolium*: First leaves separated
662051	*Epilobium angustifolium*: Inflorescence visible
662060	*Epilobium angustifolium*: First flowers open
662089	*Epilobium angustifolium*: Fruits fully ripe
662092	*Epilobium angustifolium*: Leaves beginning to discolour
662097	*Epilobium angustifolium*: Above ground organs dead
663010	*Fragaria vesca*: First leaf emerging
663051	*Fragaria vesca*: First flower buds visible
663060	*Fragaria vesca*: First flowers open
663089	*Fragaria vesca*: Fruits fully ripe
663097	*Fragaria vesca*: Above ground organs dead
664010	*Geranium sylvaticum*: First leaves separated
664031	*Juniperis communis*: Axes of developing shoots visible
664051	*Geranium sylvaticum*: First flower buds visible
664060	*Geranium sylvaticum*: First flowers open
664089	*Geranium sylvaticum*: Fruits fully ripe
664092	*Geranium sylvaticum*: Leaves beginning to discolour
664097	*Geranium sylvaticum*: Above ground organs dead
666010	*Vaccinium myrtillus*: First leaves seperated (mouse ear)
666031	*Vaccinium myrtillus*: Axes of developing shoots visible
666051	*Vaccinium myrtillus*: First flower buds visible
666060	*Vaccinium myrtillus*: First flowers open
666086	*Vaccinium myrt*illus: First ripe fruits
666092	*Vaccinium myrtillus*: First autumnal leaf colouring
666097	*Vaccinium myrtillus*: End of autumnal leaf fall (95% fallen)
669010	*Populus tremula*: First leaves seperated (mouse ear)
669011	*Populus tremula*: Leaf unfolding(first visible leaf stalk)
669060	*Populus tremula*: First flowers open

669094	*Populus tremula*: Autumnal colouring of leaves (50%)
669097	*Populus tremula*: End of autumnal leaf fall (95% fallen)
780060	*Laurus nobilis*: First flowers open
781060	*Olea europea*: First flowers open
781065	*Olea europea*: Full flowering
781069	*Olea europea*: End of flowering
782060	*Prunus amygdalis/dulcis*: First flowers open
782065	*Prunus amygdalis/dulcis*: Full flowering
782069	*Prunus amygdalis/dulcis*: End of flowering
782086	*Prunus amygdalis/dulcis*: First fruits fall naturally
783060	*Rosmarinus officinalis*: First flowers open

Appendix III. *Tables of COST 725 database*

country_code

country_name	varchar(30)	not null	
country_id	tinyint	not null	

pheno_data

station_id	int	not null	
country_id	tinyint	not null	link to table country_code
phase_id	int	not null	link to table phase_code
year	smallint	not null	year of observation
day	smallint	not null	day of year

phase_code

table_id	tinyint	not null	/*depends on plant (1-5) */
plant_id	int	not null	/* depends on BBCH */
phase_id	int	not null	link to table pheno_data
phase_text	varchar(100)	not null	complete description
table_name	varchar(40)	not null	name of table
plant_name	varchar(100)	not null	name of plant
phase_name	varchar(100)	not null	name of phase

pheno_stat

station_id	int	not null	link to table pheno_stat
country	varchar(20)	not null	link to table country_code
name	varchar(40)	not null	station name
longitude	int	not null	degree degree minute minute
latitude	int	not null	degree degree minute minute
altitude	int	not null	meter
distance	real	null	distance to coast
district	varchar(50)	null	district
phytogeo	varchar(50)	null	phytogeographical zone
met_station1	varchar(50)	null	nearest meteorological station
met_station_x	varchar(50)	null	nearest met. station, longitude
met_station_y	varchar(50)	null	nearest met. station, latitude

flag_national

value	smallint		national flag value
country_id	tinyint		link to table country_code
text	varchar(250)		description of flag

flag_serial

value	tinyint		serial flag value
text	varchar(250)		description of flag

flag_spacial

value	tinyint		spatial flag value
text	varchar(250)		description of flag

constraint

country_id	tinyint		link to table country_code
phase_id	int		link to table phase_code
lower_level	smallint		minimum DOY
upper_level	smallint		maximum DOY
Lower_altitude	smallint		minimum altitude
Upper_altitude	smallint		maximum altitude

Appendix IV. *Flagging values*

flag_serial can display the following values:

- 0 unknown
- 1 original and correct
- 2 original and suspicious, outside thresholds
- 3 original and suspicious, derivation >= 3*sigma (outlier or new extreme)
- 4 original and suspicious, outside thresholds and derivation >= 3*sigma (outlier or new extreme)
- 5 changed and correct
- 8 too less data to check
- 9 virtually deleted

flag_spatial can display the following values:

- 0 unknown
- 1 original and correct
- 2 original and suspicious, outside thresholds
- 3 original and suspicious, derivation >= 3*sigma (outlier or new extreme)
- 4 original and suspicious, outside thresholds and derivation >= 3*sigma (outlier or new extreme)
- 5 changed and correct
- 8 too less data to check
- 9 virtually deleted

Appendix V. *Formats for data deliveries*

Tables V.1 and V.2 show the COST 725 formats for data deliveries.

station ID	**country**	**plant and phase code**	**year**	**date**
integer (own code)	characters	6 digits	4 digits	yeardays (-61 – 366)

Table V.1: COST 725 data format

station ID	**country**	**station name**	**longitude**	**latitude**	**altitude**	**highest altitude**	**lowest altitude**	**district**	**comment**
integer	character	up to 40 character	degrees minutes	degrees minutes	meter	meter	meter	up to 40 characters	up to 255 characters
must	must	must	must	must	must	optional	optional	optional	optional

Table V.2: COST 725 meta-data format

The column 'comment' should contain information for example on closed stations or on new stations.

Working Group 2 photo

WG 2 meeting in Ljubljana, November 2007

Viera Jakubíková, Andreja Sušnik, Ola Langvall, Bogo Habič (back row), Sara Mulder, Zalika Crepinsek, Iztok Matajc (back row), Elisabeth Koch, Pavol Nejedlik, Eeva Pudas, Claudio Defila (back row), Katarzyna Jatczak, Marius Teodosiu (back row), Gaston Demarée (back row), Gunta Grisule, Wolfgang Lipa (back row), Nicole Estrella, Kirsten Zimmermann (back row), Alison Donnelly, Susanne Zach-Hermann (back row), Marko Zmrzlak (back row), Ana Žust, Jiří Nekovář.