

ANALYSES AND GEOVISUALIZATION OF PHENOPHASES

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Abstract

Phenology can be described either as the study of natural events, or of biological events, in relation to climate. Phenology observations are important not only in relation to climate changes. The results are applied in agriculture, forestry and also in health service. Information about certain life manifestations of organism may help to predict their occurrence, e. g. pests, to establish the most suitable forms of stand protection and to offer advance information to people suffering from pollen allergies etc. The Czech Hydrometeorological Institute operates phenological network with 45 wild plants' observing programme including allergology important species. Palacky University in Olomouc is the leading research institution in geovisualization - modern approaches to the analysis of individual elements characterizing the phenological conditions of the Czechia were used when compiling the Phenological Atlas of Czechia. The atlas concept and processing methods are based on theoretical principles as well as the contemporary level of knowledge in the field of phenology, climatology, geoinformatics and cartography. Phenology has made substantial progress during recent years in various aspects like phenological modelling, satellite observation of the vegetation cycle, relation with climate variability and others. Thanks to the collaboration of experts from various fields and institutions it was possible to present spatial variability of phenological data of plants in a series of geovisualisations presenting various phenophases. Results in this paper are focused on theoretical background of research.

Keywords: Geovisualization, Phenology, Phenophases

1. INTRODUCTION

Study of natural events in relation to climate is dealing with phenology. Same as in other scientific research it is very important to present the results for the general public and experts (Nekovář, Hájková, 2010). Very valuable and lasting way of presenting results analyses of spatial data is the form of map. Thanks to the collaboration of experts from various fields and institutions it is possible to present phenological data focused on the Czech Republic by the form of set of maps.

Main collaboration took place between three institutions - The Czech Hydrometeorological Institute, The National Institute of Public Health and Palacky University Olomouc. The Czech Hydrometeorological Institute operates phenological network with 45 wild plants' observing programme including allergology important species. The National Institute of Public Health operates aerobiological network. Palacky University in Olomouc is the leading research institution in geovisualization, map and atlas production and geographic information research.

This paper is focused on the theoretical background of research, which included analyses of data from the phenological network. Results of the research will be included in the Phenological Atlas of Czechia.

2. PHENOLOGY AND PHENOLOGICAL STAGES

Phenology is derived from the Greek word *phaino*, meaning to show or appear. It is the scientific discipline that explores the time course of periodically recurring life manifestations of plants. These periods are called phenological stages. Phenology also explores their link with weather and climate, including soil conditions. Phenology observations have high importance as an irreplaceable indicator of changes in the environment (Hájková et al., 2007). In the 4th assessment report of the Intergovernmental Panel on Climate Change the results of phenological research play a major role in assessing the observed changes in natural and manager systems.

Phenophases (phenological stages) present according to USA National Phenology Network (USA-NPN, 2010) an observable stage or phase in the annual life cycle of a plant or animal that can be defined by a start and end point. Phenophases generally have duration of a few days or weeks. Phenological stages can describe leaf unfolding and flowering of plants in spring, fruit ripening, color changing and leaf fall in autumn, as well as the appearance and departure of migrating birds and the timing of animal breeding are all examples. For this research there were used data from the Czech Hydrometeorological Institute – it means data from the phenological network with 45 wild plants' observing programme including allergology important species.



Fig. 1. Illustrative example of phenological observation of the plant (Biology Online, 2010)

3. SPATIAL MODELLING AND GEOVISUALIZATION

Data of phenological stages are usually presented in a form of graphs and charts. In fact, one map can compensate many of those charts and graphs (Voženílek, 2005). Therefore there was created a series of maps presenting various phenophases according to data from the network with 45 wild plants' observing programs. These maps are created in the scope of the whole territory of the Czech Republic.

3.1 Map creation

Maps are created by interpolating the data from the phenological stations. In each map it is very important to determine the proper distribution of values in the frequency graph and then to determine the proper intervals for visualization entries of selected phenophases for different regions of the Czech Republic (Fig. 2).

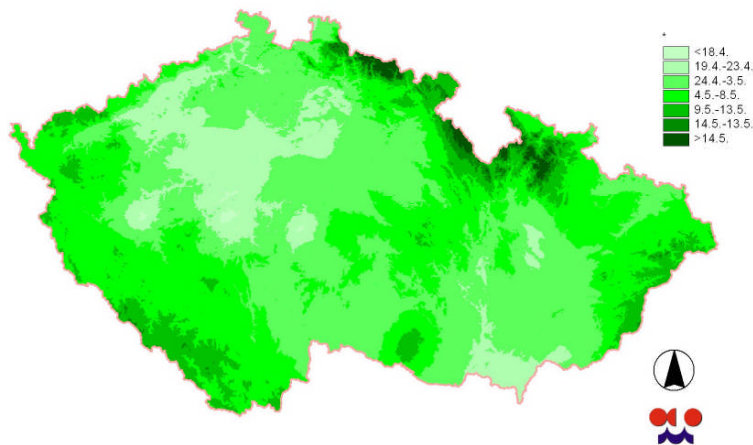


Fig. 2. Final grid of birch – first leaves.

In addition to the resulting grid, for which an appropriate color scale is chosen (Fig. 3), the map includes additional layers such as the Czech Republic major cities, major rivers and water areas, etc. (Fig. 4). Area around the Czech Republic is shown as a terrain relief with major cities and rivers. For each phenological stages of a plant is created one map.

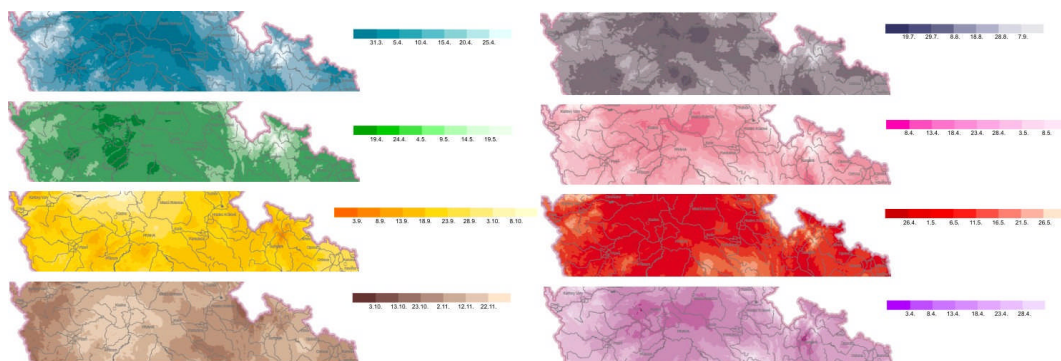


Fig. 3. Example of color scales for different types of phenological stages.

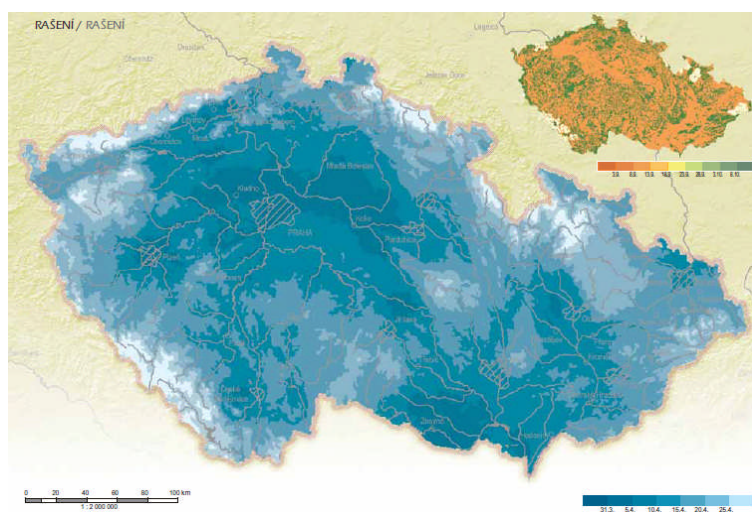


Fig. 4. Example of final map with all compositional elements.

4. PHENOLOGICAL ATLAS OF CZECHIA

There was created a series of maps focused on field crops, fruit trees, wild plants – trees and wild plants, which became the basis for making Phenological Atlas of Czechia. Its main feature is the modern approach to the analysis of individual elements characterizing the phenological conditions of the Czech Republic.

The atlas concept and processing methods are based on theoretical principles as well as the contemporary level of knowledge in the field of phenology, climatology, geoinformatics and cartography. The work has come into being thanks to the collaboration and understanding of authors from various fields, whose objective was to meet the goals and criteria required from a scientific publication.

The general content of chapters are maps, graphs and tables with text and botanical specification of each plant. The essential emphasis is placed on allergology important phenophases at allergology important plants. Also there is included text about the history of Czech phenological observations and comparison with European phenology network.

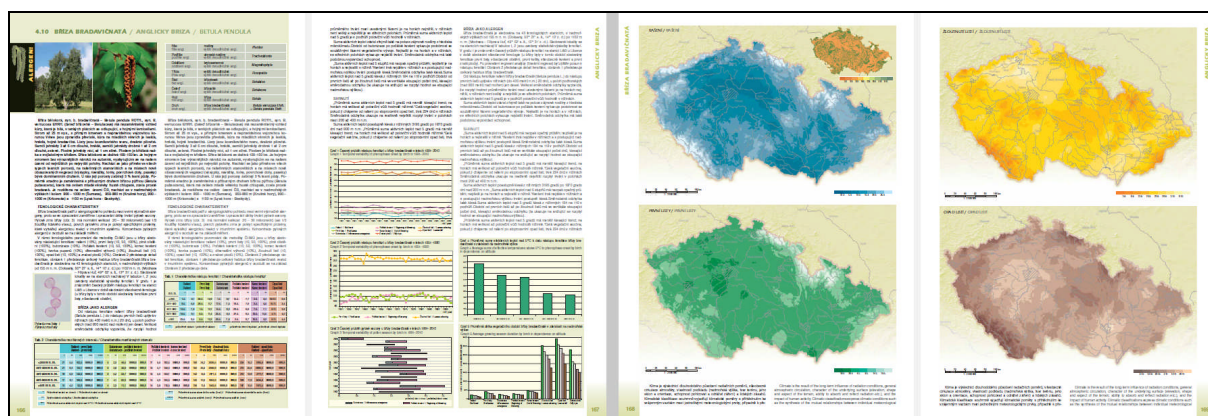


Fig. 5. Sample pages of prepared draft of Phenological Atlas of Czechia.

Maps are used in three different scales: 1 : 1 000 000 for interesting general characteristics, 1 : 2 000 000 for each phenophases of plants and 1 : 5 000 000 for additional maps. As a topographic background there are used rivers and state borders.

CONCLUSION

Nature and its exploration is one of the most frequent objects of scientific research. Study of natural events, or of biological events, in relation to climate deals with phenology. Phenological observations are important not only in relation to climate changes - the results are applied in agriculture, forestry and also in health service.

The best way how to present phenological information for general public, could be a series of maps, which have been designed during this research. Thanks to the collaboration of experts from various fields and institutions it was possible to present spatial variability of phenological data of plants in a series of maps presenting various phenophases according to data from the network with 45 wild plants' observing programs. This paper is focused on the theoretical background, concrete result of analyses of each plant will be presented as a part of Phenological Atlas of Czechia. All maps were created in the scope of the whole territory of the Czech Republic.

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REFERENCES

- Biology Online. Web site <http://www.biology-online.org/articles/phenology_flowering_starch_accumulation/figures.html>. Date of citation 15-09-2010.
- Hájková L, Sedláček V., Nekovář J., 2007. Temporal and spatial variability of the most important phenological phases of birch in the Czech republic. FOLIA OECOLOGICA – vol. 34, No. 2, p. 86 – 96. ISSN 1336-5266
- Hájková, L., Jakubíková, V., Richterová, D., 2009. Pollen season duration of winter rape (*Brassica napus* L.) in Czech and Slovak republic. Bioklimatologická conference s mezinárodní účastí “Sunstainable development and bioclimate”, 5. – 8. 10. 2009, Stará Lesná, ISBN 978-80900450-1-9, s. 150
- Hájková, L., Nekovář, J., Novák, M., Richterová, D. 2009. Assessment of vegetative phenological phases of European beech (*Fagus sylvatica* L.) in relation to effective temperature during period of 1992 – 2008 in Czechia . Bioklimatologická conference s mezinárodní účastí “Sunstainable development and bioclimate”, 5. – 8. 10. 2009, Stará Lesná, ISBN 978-80900450-1-9, s. 85
- Hájková, L., Nekovář, J., Richterová, D. 2009. Temporal and spatial variability in allergy-triggering phenological phase of hazel and alder in Czechia. FOLIA OECOLOGICA, vol. 36, No. 1, p. 8 – 19, ISSN 1336-5266
- Nekovář, J., Hájková, L. 2010. Fenologická pozorování v Česku – historie a současnost. Meteorologické zprávy, ročník 63, č. 1, s. 13 -20, ISSN 0026-1173
- Tolasz, Radim et al. *Atlas podnebí Česka*. 1. vyd. Praha: Český hydrometeorologický ústav; Olomouc: Univerzita Palackého v Olomouci, 2007 255 s. ISBN 9788086690261 (ČHMU). ISBN 9788024416267 (UP).
- USA-NPN: USA National Phenology Network. Web site <<http://www.usanpn.org/about/phenology>>. Date of citation 15-09-2010.
- Voženílek, V. *Cartography for GIS: geovisualization and map communication*. Univerzita Palackého v Olomouci, 2005, Olomouc. ISBN 80-244-1047-8.
- Zahradníček, P., Hájková, L. 2009. Vliv meteorologických prvků na vybrané fenologické fáze révy vinné a jejich časová dynamika. Meteorologické zprávy, ročník 62, č. 3, s. 80 – 88, ISSN 0026-1173.