Aerologic-climate data in relation to the development of plants in Central Europe

Ivan Kott[1], Jiří Nekovář[1], Pavel Kouba[2]

[1] Czech Hydrometeorological Institute, Na Šabatce 17, Prague 4 – Komořany 143 06, [2]Czech Hydrometeorological Institute, Observatory Libuš, Prague 4 – Libuš, Czechia

Abstract. For the evaluation of a closer relationship to the natural phenomena they recently North Atlantic oscillation index is often used (NAOi), who, to put it simply – indicates a dynamic difference in air pressure between the Azores and Iceland. It seems that correlates very well with the NAOi situations in Western Europe (Iberian Peninsula, France, Ireland and Great Britain, Benelux, western area of southern Norway). For the area of Central Europe (Central and southern Germany, Switzerland, Austria, the Czech Republic and Slovakia, Poland) is based on a good correlation when the supply of air masses in the sector from the Southwest along the Northwest. While it is true that these situations tend to be about 2/3 of all, but especially in the winter, it is frequently different. Nevertheless N-NE-E-SE-S situations are in good correlations with the onset of phenological phases. Effort to create a triangle between Azores pressure levels and the pressure reduced, along with Siberian extreme is not successful. That's why we have chosen to attempt to triangle between the North Germany (Hamburg), South of Germany (Munich) and important indicators of pressure fields to the East of Germany (Vienna, Pratur-Libuš and Prostějov), that are in the data availability for presenting authors.

Key words

Oscillation index – plant development - Europe

Introduction

We decided to compare key stations (Schleswig, Munich) to the station in the "center stage" Prague-Libuš and Prostějov as the third point of triangle. The next version was the effort to simplify the triangle on "bilateral" type of the Azores-Iceland in the way that we consider one point at the station, Schleswig, and as an additional clue the average of the "Southern" sations.

Material and methods

In the winter season (November – March) we have chosen the following year dated the situation relevant to the advent of the pre-early spring phase (Goat Willow, Hazel, Snowdrop, Coltsfoot, Alder). The smaller the correlation relationship is with spring stages (Birch) and very free in late-spring phenophases (flowering of Meadow Foxtail snd Cocks Foot).

In this work was to evaluate the relationships between aerology-phenological and climatic phenomena selected phase inflorescence emergence (IE), the beginning of flowering (BF) and the end of flowering (EF) is the primary alergological of important species with early spring flowering, along with some species with a very early crop plants (Snowdrop, Anemone, Coltsfoot).

Aerological data includes information about the air pressure on the four selected stations, the height of the pressure fiekd of 850 and 500 hPa, including data on temperature and relative humidity, wind speed and direction in these categories and on the ground floor.

The phenological dates were given from alergological point of view takes precedence over the inflorescence emergence, the beginning snd the end of the flowering and of such plant species that react sensitively to the previous weather trends, especially in the period from November to March. A detailed analysis was made of the relationship between aerologic-climatic and phenological development in the time interval between 2001 and 2011. Phenological data was obtained from observation of Hazel, Birch, Alder, Willow, Meadow Foxtail and Cocks Foot, as well as Snowdrop, Anemone and Coltsfoot. Aerological data comes from the measurement of the five stations engaged in this activity in Europe, (from North to South):

Station	Indicative	Height	Latitude	Longitude	Distance
Schleswig	10035	47 m	N54°13	E 9°41	603 km
Prague-Libuš	11520	303 m	N50°4	E14°27	0 km
Prostějov	11747	226 m	N49°4	E17°10	203 km
München	10868	489 m	N48°8	E11°34	262 km
Wien	11035	198 m	N48°2	E16°4	242 km

The working title of the indicators (the index) is MEOi (Middle European Oscillation index). It is based about comparing broad-synoptical intervals between focal point (Prague-libuš) and points Northwest (Schleswig), Eastern (Prostějov), Southwest (München) and Southern (Wien). The source data were included the following data from daily measurement: air pressure [hPa], geopotential level [m], air temperature [°C], relative humidity [%], wind direction [grad] and wind speed [m.s^{-1}].

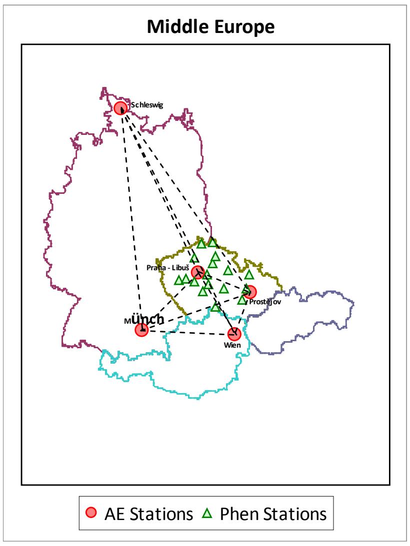

Figure 1. *Schematic map of aerological and phenological stations*

For basic processing was used aerological data from 00:00 UT for each day of the period XI – III, followed by further processing after pentade (that best correspond to the scattering of phenological observations about the exact date of phenophase), and finally, with the application of the calculation of the average differential of geopotential levels, pertaining to 850 hPa from multiannual (11-years, 2001-2011) average, it was possible to campare the average values for the period XI – III each year, the observed data phenological phases of plant species.

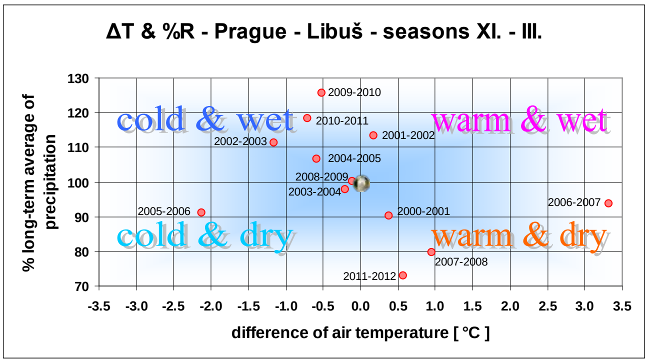

Figure 2. *Visual evaluation of the temperature and precipitation deviatioín from mean value of 1971 to 2000 year (evaluated seasons XI. – III.)*

In the first step of calculation has been used relationship:

$$MEOi_{pent} = (\Delta S) - ((\Delta L + \Delta M + \Delta W + \Delta P)/4)$$

Where Δ is geopotential 850 hPa level difference from the average 11- years (after pentade period calculation XI – III) between S … Schleswig and average of other stations: L means Prague-Libuš, M means München, W means Wien and P is Prostějov.

Calculate the average of the results of pentades followed in the period XI – III each year, and then calculate the correlation coefficient for a set of indexes, and phenophases, together with the findings of the tightness of their mutual relations.

Phenological data was used from total of 16 stations observing the forest plants. The following charts (a random selection from a total of 168) represent the initial stage in the first place – inflorescence emergence – within the meaning of the ordinal day of the year (see the Y axis to the left). A follow–up column above the level so determined then indicate the duration of the applicable period in the number of days between the onset of inflorescence emergence until the beginning of flowering and the flowering from the beginning to the end of flowering stage in the years to come. The snowdrop and coltsfoot are observed only the beginning and the end of the flowering stage. Strong angled lines with light node points expresses the values of experimental points form MEO index related to the spring phenophases in the respective years. Values of the index are on a secondary Y axis on the right.

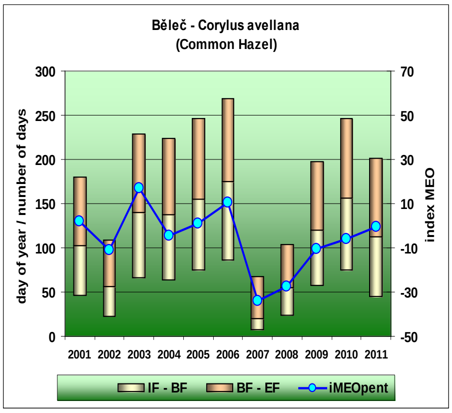

Figure 3. *Comparison between MEOi and phenophases of Hazel (Station Běleč)*

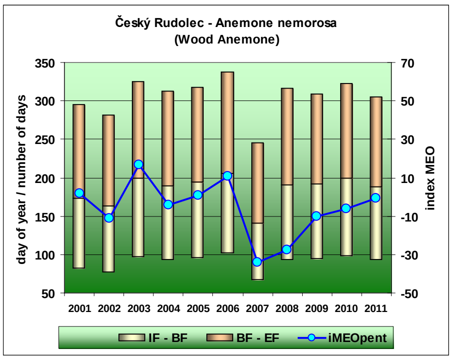

Figure 4. *Comparison between MEOi and phenophases of Wood Anemone (Station Český Rudolec)*

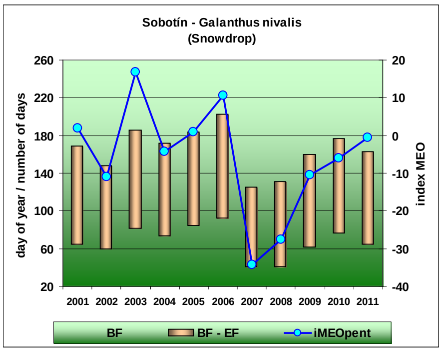

Figure 5. *Comparison between MEOi and phenophases of Snowdrop (Station Sobotín)*

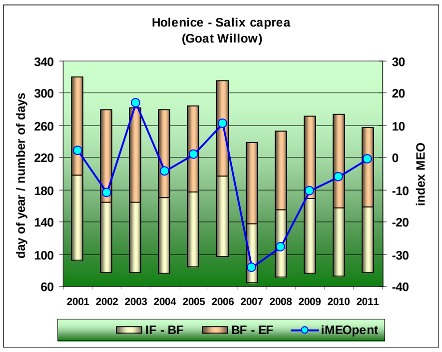

Figure 6. *Comparison between MEOi and phenophases of Willow (Station Holenice)*

Results and disscussion

The following summary tables represent the tightness degree of the relation to the phenophases with MEOi meeting or failing to meet the levels of acceptance at the level of p = 0,10, p = 0,05, p = 0,01 and p = 0,001. These values of correlation coefficients are marked (respectively) the symbols *, **, *** and ****.

Table 1. *Corylus avellana (Hazel) and Alnus glutinosa (Alder)*

CORREL Phen&iMEO		Corylus avellana			Alnus glutinosa		
Station	H [m]	IF	IF - BF	BF - EF	IF	IF - BF	BF - EF
Doksany	158	★★ 0.7232	★★★ 0.7728	★★★★ 0.8538	★★ 0.7074	★★★ 0.7846	★★★★ 0.8925
Běleč	241	★★★ 0.7845	★★★ 0.8395	★★★★ 0.8499	0.4511	0.1593	0.1073
Seletice	260	★ 0.5705	0.4824	★★★ 0.7548	★ 0.5372	0.3324	0.0786
Plzeň-Bolevec	328	★★ 0.6861	★ 0.5673	0.4798	0.3027	0.2812	0.2593
Kostelec n. Č. l.	345	★ 0.5221	★ 0.5865	★★ 0.6930	0.3875	★ 0.5286	★★★ 0.7701
Chřibská	350	★★★ 0.7486	★★★ 0.8317	★★ 0.7065	0.4748	0.4799	0.3759
Vlašim	350	★★★ 0.7639	★★★ 0.8036	★★★ 0.8387	★★ 0.6856	★★★ 0.7858	★★ 0.7259
Krakovec	400	★★★ 0.7974	★★★ 0.8224	★★★ 0.8238	—	—	—
Holenice	415	★★★ 0.7539	★★★ 0.8195	0.3720	★★★ 0.7531	★★★ 0.8092	0.4220
Sobotín	425	★★★ 0.8045	★★★ 0.8286	★★★ 0.8413	★★★ 0.7660	★★★ 0.7920	★★★ 0.7815
Březina	430	★★ 0.7056	★★★ 0.7865	★★★ 0.7634	—	—	—
Dobříš	430	★★★ 0.7517	★★★ 0.7924	★★★ 0.7623	0.4102	0.3496	0.2999
Zbiroh	490	★★★ 0.7430	★★★ 0.7610	★★★ 0.8197	★ 0.5967	★★ 0.6207	★★ 0.7141
Nemyšl	510	0.3163	0.3212	0.4640	0.0867	0.1641	★★ 0.6832
Přibyslav	530	★★★★ 0.8888	★★★★ 0.8773	★★★ 0.8131	★★★★ 0.8685	★★★★ 0.9123	★★★★ 0.9349
Český Rudolec	540	★★★ 0.7662	★★★ 0.8363	★★ 0.6913	★★★ 0.7459	★★★ 0.7739	★ 0.5974

Table 2. *Salix caprea (Willow) and Betula verrucosa (White Birch)*

CORREL Phen&iMEO		Salix caprea			Betula verrucosa		
Station	H [m]	IF	IF - BF	BF - EF	IF	IF - BF	BF - EF
Doksany	158	★★★ 0.8072	★★ 0.6900	★★ 0.6310	★ 0.5776	★★ 0.6283	0.1915
Běleč	241	★★★ 0.7604	★★ 0.6970	★★ 0.6407	★ 0.5836	★★ 0.6756	★ 0.5672
Seletice	260	0.0657	0.2830	★★ 0.6614	-0.120	-0.296	0.0337
Plzeň-Bolevec	328	0.3524	0.0738	-0.014	★★★★ 0.8543	★★★ 0.7666	0.5037
Kostelec n. Č. l.	345	0.0419	0.0439	0.3525	-0.055	0.4458	★ 0.5395
Chřibská	350	★★★ 0.8014	★★★ 0.8137	★ 0.5304	0.4026	0.3423	0.3618
Vlašim	350	★★★ 0.8415	★★★ 0.7657	★★★ 0.8367	★ 0.5933	★★ 0.6815	0.0909
Krakovec	400	★★ 0.6986	★★★ 0.7556	★★★ 0.7546	★★ 0.6199	★★ 0.6999	★★ 0.7095
Holenice	415	★★ 0.6975	★★ 0.6222	★★ 0.6548	0.3379	0.4949	0.3003
Sobotín	425	★★ 0.6155	★★★ 0.7702	★★★★ 0.8905	★★★ 0.7590	★★ 0.6918	0.5119
Březina	430	★★ 0.6225	★★ 0.7316	★★ 0.7314	0.0161	-0.275	-0.290
Dobříš	430	★★★ 0.7612	★★ 0.7041	0.5150	★ 0.5445	★★ 0.6948	★ 0.5485
Zbiroh	490	★★★ 0.8168	★★ 0.6299	★★ 0.7059	0.3048	★★ 0.6029	0.4983
Nemyšl	510	0.4567	★★ 0.6896	0.4915	0.1748	0.0133	-0.134
Přibyslav	530	0.4331	★ 0.5432	★ 0.5870	0.1118	0.3539	-0.084
Český Rudolec	540	0.4953	★★★ 0.8086	★★ 0.6335	0.4262	★ 0.5504	0.3137

Table 3. *Tussilago farfara (Coltsfoot) and Anemone nemorosa (Wood Anemone)*

CORREL Phen&iMEO		Tussilago farfara		Anemone nemorosa		
Station	H [m]	BF	BF - EF	IF	IF - BF	BF - EF
Doksany	158	—	—	—	—	—
Běleč	241	★★★ 0.8353	0.2782	0.5120	★★ 0.6083	0.3170
Seletice	260	0.2689	-0.154	-0.033	0.4473	★★ 0.6086
Plzeň-Bolevec	328	—	—	—	—	—
Kostelec n. Č. l.	345	★★ 0.7144	★★★ 0.8057	★★★ 0.8470	★★★ 0.8271	★★★★ 0.8556
Chřibská	350	0.3886	-0.233	★ 0.5662	0.4271	★ 0.5322
Vlašim	350	0.4791	★★ 0.6479	★★★ 0.7945	★★★ 0.8352	★ 0.5462
Krakovec	400	—	—	★★★★ 0.9324	★★★★ 0.9558	★★ 0.6559
Holenice	415	★ 0.5451	★★ 0.7052	★★ 0.7179	★★ 0.7044	★★ 0.6945
Sobotín	425	★★ 0.6803	★★★ 0.7402	★★ 0.7211	★★★ 0.7505	0.4658
Březina	430	—	—	★ 0.5866	★ 0.5556	0.3116
Dobříš	430	★★★ 0.7660	0.1843	0.4646	0.5157	0.4525
Zbiroh	490	★★ 0.6288	★ 0.5514	0.4293	★ 0.5228	0.4678
Nemyšl	510	-0.170	-0.038	-0.046	-0.011	0.0399
Přibyslav	530	0.4741	★★ 0.7150	★★★ 0.8418	★★★★ 0.8668	0.0316
Český Rudolec	540	0.0634	0.2072	★★ 0.6223	★★ 0.6796	★★ 0.6640

Table 4. *Alopecurus pratensis (Meadow Foxtail) and Dactylis glomerata (Cocks Foot)*

CORREL Phen&iMEO		Alopecurus pratensis			Dactylis glomerata		
Station	H [m]	IF	IF - BF	BF - EF	IF	IF - BF	BF - EF
Doksany	158	0.3545	0.4164	0.0934	0.4473	★ 0.5473	0.3046
Běleč	241	★★ 0.6951	★★ 0.6620	★★ 0.6109	0.6974	★★★ 0.7350	★★★ 0.7442
Seletice	260	-0.044	-0.080	0.1874	0.1400	-0.155	0.2254
Plzeň-Bolevec	328	0.1891	-0.058	0.3851	—	—	—
Kostelec n. Č. l.	345	0.4953	0.0357	0.0772	0.4261	0.1341	0.1593
Chřibská	350	-0.091	0.2027	0.3339	-0.003	0.1091	★ 0.5941
Vlašim	350	0.4615	0.4405	0.0999	★ 0.5234	0.4736	★★ 0.6064
Krakovec	400	—	—	—	—	—	—
Holenice	415	★ 0.5776	★ 0.5727	★★ 0.7017	0.4105	0.4007	0.1230
Sobotín	425	★★★ 0.7910	0.3707	0.0938	0.5129	★★★ 0.7684	0.1525
Březina	430	0.3078	0.3893	-0.053	0.3245	0.2478	0.1723
Dobříš	430	0.0565	0.3778	0.4051	0.3486	★ 0.5610	0.2775
Zbiroh	490	★ 0.5458	0.5172	0.2353	0.3068	0.5193	-0.002
Nemyšl	510	-0.210	-0.117	-0.715	—	—	—
Přibyslav	530	0.4369	0.5074	★ 0.5337	0.5096	0.3528	0.4839
Český Rudolec	540	0.4792	0.3704	0.2356	0.4191	0.2644	0.1419

Conclusion

Results of the assessment, it is evident that the tightness of relationships between MEOi and PHEN (phenophases) not elevation or spatial distance, but mainly the approach to the period XII – III.

This work is only the first zoom in to the final solution. Starting from comparison of fluctuations in geopotential levels at the level of pressure 850 hPa, we consciously simplify otherwise complex dynamics in the troposphere.

In the following, we are going to continue to deal with calculations in the wider concept taking into account other relevant factors (wind speed and direction, air temperature, relative humidity). However, it is certainly an interesting finding, that the first – so far a very rude – preview on the overall situation in Central Europe suggests a positive direction of the solution.

As another fact needs to be borne in mind that the duration of the evaluated period (2001 – 2011) was too short for an exact conclusions. This limitation was subject to mostly fair availability of data from the aerological measurement. Even this aspect in future follow-up work we intend to more broadly address.

Last but not least we also increase the use of appropriate methods of data processing, for example application of the method of neural networks.

Acknowledgements. Autors thank to Ms Kirsten Zimmermann from DWD Offenbach am Main, Germany and Mr Wolfgang Lipa (ZAMG, Wien, Austria) for aero-stations data.

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