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## ROLE OF THE INDEX OF VERTICAL CHANGEABILITY OF WIND IN THE DYNAMICS OF MACRO-, MESO- AND TOPOCLIMATE OF THE BALTIC SEA SHORE

*Abstract:* Several circulation indices in different spatial scales and at different levels are calculated for the area: 20°W-30°E, 50°N-70°N. The relationship between the zonal circulation index and the spatial variability of the regional indices at different levels (925, 700, 500 hPa) is then established for the chosen period of sequential changes of the zonal circulation index with the usage of the correlation and time series analysis. Afterwards, their role in the reaction of the temperature field (at 925 hPa) over the Baltic Sea Basin was investigated.

*Key words:* western flow dynamics, regional circulation indices, temperature field's response to synoptic forcing.

### 1. Data and Methods

A factor, which is of decisive importance when considering the weather situations, which in turn can be regarded as isolated states of the climatic system as a whole, is atmospheric circulation. In different spatial scales its predominant influence is quite often modified by geographical factors. The objective of the research was the establishment of the role of the European continent as a modifying factor in a couple of chosen atmospheric circulation indices, characterising the predominant western flow of the air over the area of research. Afterwards, the response of the temperature field to the changes of the circulation indices (due to the intercontinental Baltic Sea Basin and surrounding land areas) was investigated. In the paper, grid data (NCEP/NCAR Reanalysis) acquired from NOAA/CIRES CDC Boulder, Colorado, USA, was used (Kalnay et al. 1996). Temporal coverage was 1981-90, spatial resolution was 2.5x2.5 degree and their vertical extent ranged from 1000 to 500 hPa. During the research only a part of the available variables were used i.e.: wind velocity vector components ( $U$ ,  $V$ ), geopotential heights of isobaric surfaces and air temperature at the chosen levels.

The most general circulation characteristic – zonal circulation index ( $I_c$ ) was calculated from the formula:

$$I_c = h_{40} - h_{65}$$

where:

$h_{65}$  – average height of 500 hPa isobaric surface on  $\phi=65^\circ\text{N}$

$h_{40}$  – average height of 500 hPa isobaric surface on  $\phi=40^\circ\text{N}$

The index was calculated with a 6-hourly time step for the area defined by the following coordinates:  $\phi=40^\circ\text{N}-65^\circ\text{N}$  and  $\lambda=30^\circ\text{W}-30^\circ\text{E}$ , and then standardised ( $I_{CST}$  – standardised zonal circulation index). It is believed that this index is sufficient to mirror the airflow in the middle troposphere (Sazonow et al. 1992; Wibig 1991).

The impact of the continent was analysed through the spatial and temporal dynamics of  $U$ . In order to adjust to the regional scale (Miętus 1999),  $U$  was calculated as an area average for 10 subareas with a spatial extent of  $10^\circ \times 10^\circ$ , enclosed by the coordinates:  $20^\circ\text{W}-30^\circ\text{E}$  and  $50^\circ\text{N}-70^\circ\text{N}$  (Fig. 1). The vertical variability of  $U$  was investigated at the following isobaric levels: 1000, 925, 700 and 500 hPa (in further

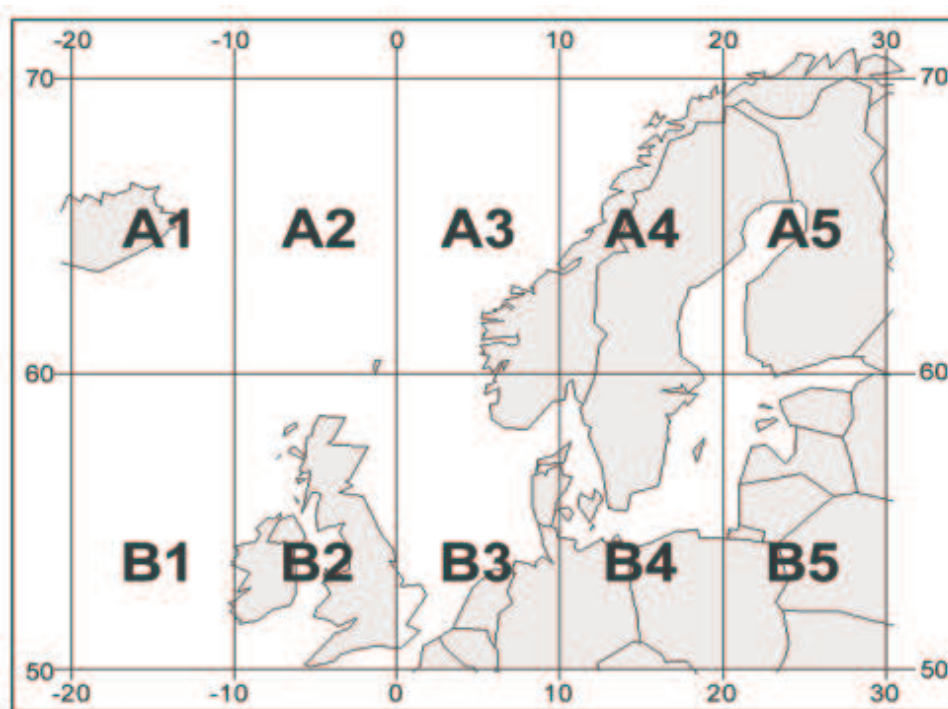


Fig. 1. Area under investigation.

analysis the 1000 hPa level was omitted). This approach allowed the establishment of the modifying impact of the surface.

The local scale (Miętus 1999) temperature field's response to macro and meso-scale synoptic forcing, has been investigated at the 925 hPa level and within an area with the following spatial boundaries: 10°E-30°E, 50°N-60°N. In order to enrich the analysis the spatial variability of temperature fields has been connected with the vorticity value (*VOR*), which allows the identification of cyclonic or anti-cyclonic flow character. It was decided that the temperature field would be the best for the analysis as it is one of the most often used variables when analysing the local climate's variability.

The relationship between  $I_{CST}$  and spatial-temporal  $U$  variability was established with the usage of the sequence of cases. A similar procedure was used in the case of temperature field analysis. Special attention was paid to check in what manner the direction and dynamics of changes of  $I_{CST}$  shapes the spatial and temporal  $U$  and the air temperature variability.

## 2. Results

$I_{CST}$  analysis revealed that in the period 1981-1990, 53 sequences occurred when at least a 5 – day period of continuous growth of  $I_{CST}$  was followed by at least a 5-day period of its decrease or the opposite. The next step involved the choice of the situation with the highest  $I_{CST}$  variability (over the 3rd quartile). From among 13 such cases, one was arbitrarily chosen and analysed in this paper in detail. It was a 19-day period at the turn of January and February in the year 1982 (Fig. 2) for which  $I_{CST}$  continually increased then decreased and again rose up. The course of  $I_{CST}$  can be divided into three phases. These and points of rapid change within the first phase have a clear reflection in the course of  $U$  for the analysed period at all the chosen levels.

$I_{CST}$  macroscale index as well as regional  $U$  values was used in correlation analysis. The vertical diversity of indices was investigated and then the connections of  $I_{CST}$  with the regional scale indices were established with the usage of time series analysis. Along with the expectations, a significant relationship was found between the correlation coefficients for individual levels. Its values in the case of  $U$  (between 500 and 700 hPa) are very high and range from 0.87 to 0.98. Noticeably lower values occur when comparing regional indices for 500 and 925 hPa levels, from 0.26 to 0.93.

Interestingly, a spatial variability of  $U$  between 500 and 925 hPa levels shows that there is continuous decrease of correlation coefficients while moving east (Fig. 3). This rule does not apply to the northern part of the area, which fact can possibly be attributed to the impact of the Scandinavian Mountains. Correlation analysis between  $I_{CST}$  and  $U$  confirms the difference between the northern and the southern part of the area. In the southern one there is a strong connection and only in the most eastern subarea (B5) the correlation coefficient between  $U$  (925 hPa level) and  $I_{CST}$  does not imply any significant connection. In the northern part, only subarea A1 reflects evident positive correlation, however, when moving east the correlation sign changes gradually into negative.

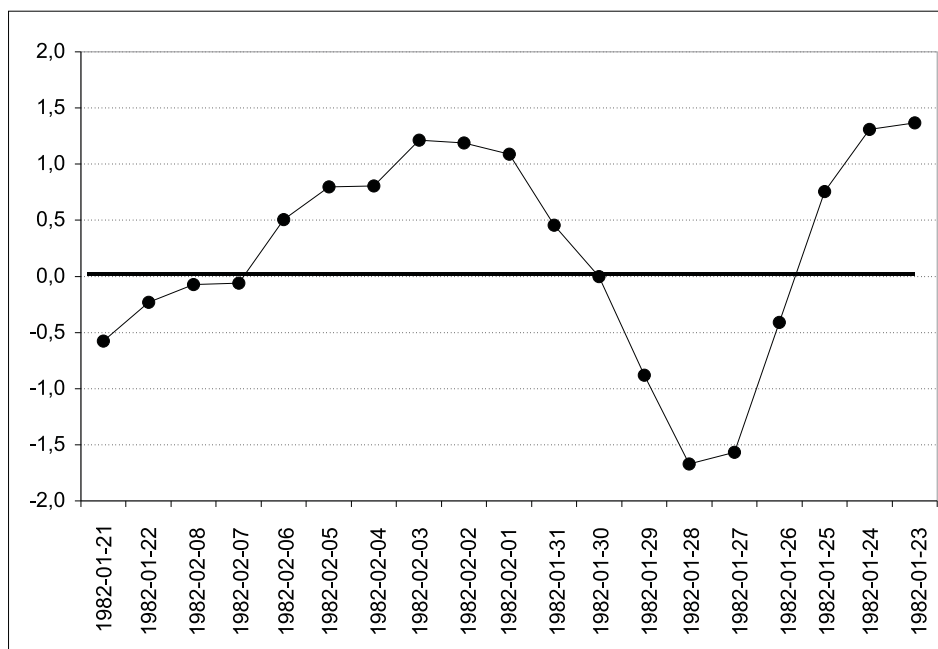


Fig. 2. 24-hour course of  $I_{CST}$  (21st Jan., 1982-8th Dec., 1982).

Fairly interesting conclusions arise when comparing the time courses of  $I_{CST}$  and  $U$ . In the southern section there is apparent conformity with respect to both the variables. An exception can be found only in the easternmost subareas B4 and B5 where the  $U$  reaction lags. The northern section bears a somehow different relationship between the analysed indices. The highest similarity in A1 gradually gets shifted back in time towards the east, however in the A4 and A5 (over the Baltic Sea Basin) subareas reasonable acceleration of the reaction of  $U$  in comparison with the changes of  $I_{CST}$  occurs. The shift is ca. 3 days.

A clear relationship exists between the spatial variability of the air temperature over the area of the (widely defined) Baltic Sea Basin and circulation indices. Distribution is dependent on the direction of advection on one side and  $VOR$ , which mirrors cyclonic or anti-cyclonic character of flow, on the other. While zonal components calculated for every level vary considerably from each other in the periods of maximum westerly flow, vorticity analysis proved strong similarities in the course of this index with respect to different levels. Influence of these indices on temperature field is illustrated by the chosen examples (Fig. 4). In the period of interest there occurred days with a very strong westerly flow. (Fig. 4a) reasonably illustrates the spatial variability of the air temperature on a day with such conditions (26th Jan., 1982). The isotherms pattern is close to meridional with soundly indicated western ridge of higher temperatures.  $I_{CST}$  values for this day are close to maximum, which

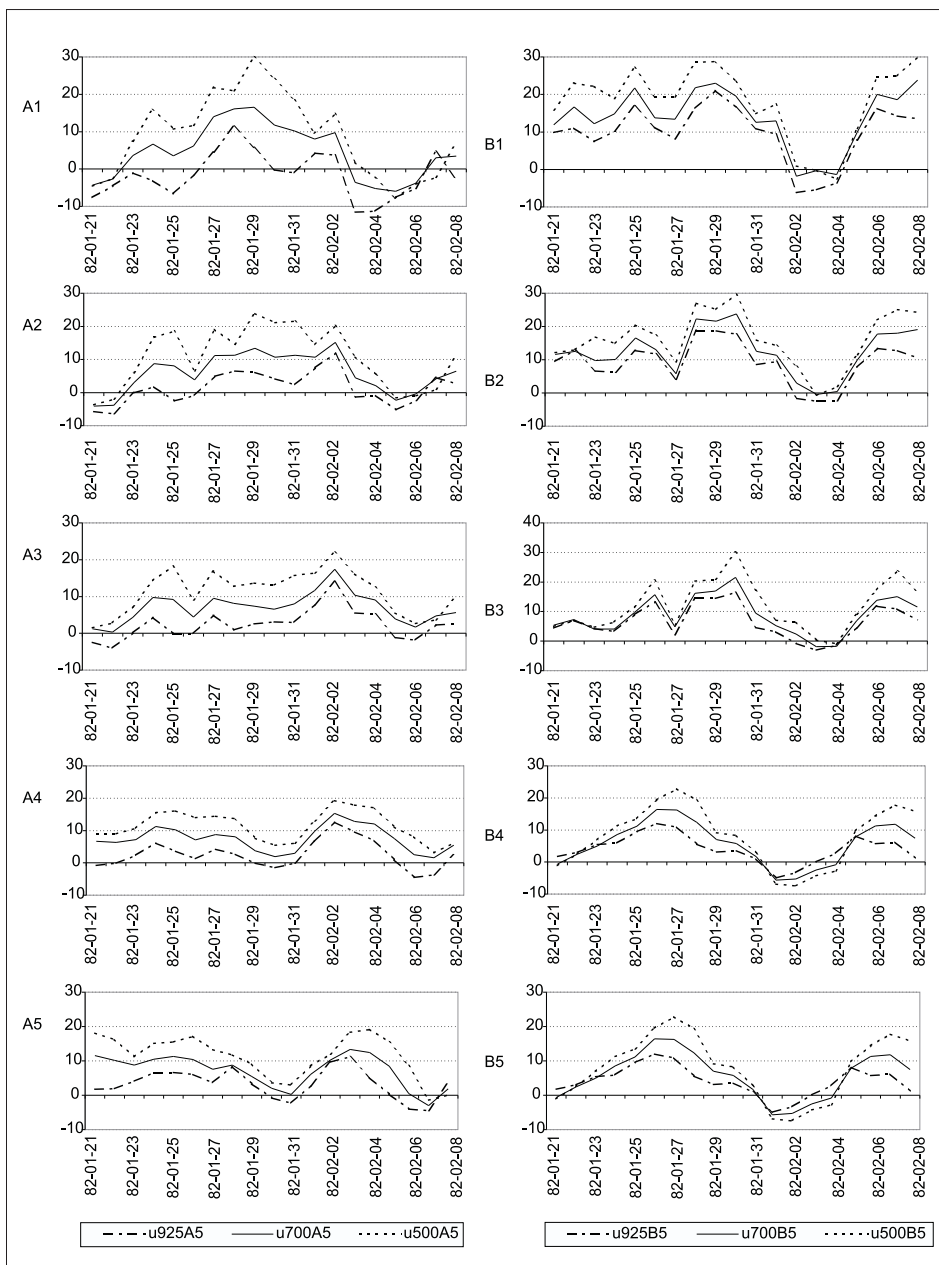


Fig. 3. 24-hour course of  $U$  at 925, 700 and 500 hPa levels for individual subareas (21st Jan., 1982-8th Dec., 1982).

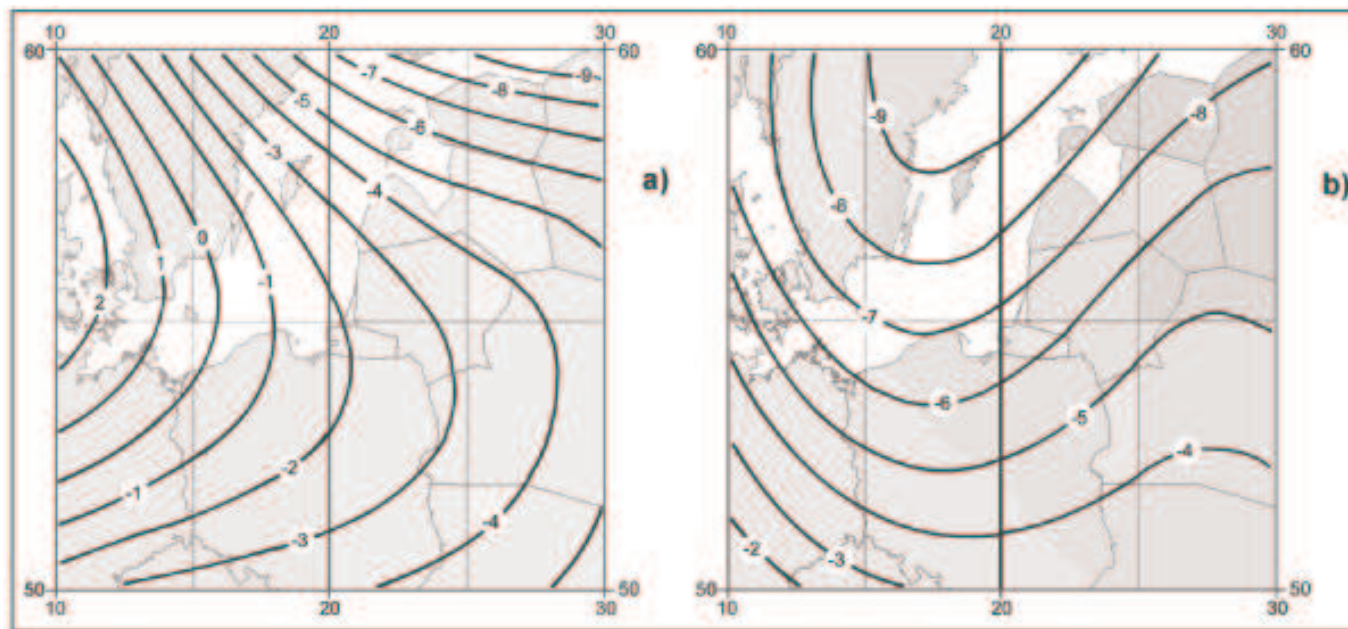


Fig. 4. Temperature fields (24-hour averages) at 925 hPa level for subareas B4 and B5:

a) 26th Jan., 1982; b) 31st Jan., 1982

fact goes along with the vorticity values for each level. A quite different situation with strong advection from the north, connected with a cyclone going toward the south-east occurred on 1982.01.31 (Fig. 4b). Differences in *VOR* between B4 and B5 subareas are pretty apparent. For B4 values of *VOR* differ at every level with respect to both the direction of changes and their values. For the 500 hPa level momentary rise can be seen while every other level experiences rapid fall of the *VOR* values. In subarea B5 maximum values (for the analysed

period), connected with the above-mentioned active cyclone, of *VOR* occurred. *V* values for that day in B4 subarea reached  $26 \text{ ms}^{-1}$ . High differences (reaching  $11 \text{ ms}^{-1}$ ) of *V* between the 925 and 500 hPa levels are worthy of special notice. The isotherm pattern during this day shows strong advection of the cold air from the north and only in the easternmost part of the analysed subarea is the influence of the cyclone noticeable.

In the paper, the introductory results of the research over the sequences in the changes of atmospheric circulation and their influence on meteorological fields dynamics, was presented. It seems that taking full analysis of synoptic sequences into consideration in synoptic climatology research may help in deeper understanding of the connection occurring between the atmospheric circulation characteristics defined in different spatial scales and spatial and temporal variability of meteorological elements. However, it is essential to use the methods that would specify the intercorrelation of time series.

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Tab. 1. Coefficients of correlations between *U* and  $I_{CST}$  at 925, 700 and 925hPa levels (21st Jan., 1982-8th Feb., 1982)

level	A1	A2	A3	A4	A5
925	0.64	0.30	-0.28	-0.62	-0.43
700	0.59	0.33	-0.26	-0.71	-0.69
500	0.47	0.26	-0.13	-0.62	-0.68
level	B1	B2	B3	B4	B5
925	0.86	0.81	0.83	0.79	0.38
700	0.89	0.87	0.87	0.86	0.70
500	0.89	0.90	0.84	0.88	0.77

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