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SENSING THE CORRELATION BETWEEN ATMOSPHERIC TELECONNECTION PATTERNS AND SEA ICE EXTENT: MICROS TECHNOLOGY "GEOMATH"

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Abstract

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It is carried out the micros computer data processing technology for sensing the correlation between atmospheric teleconnection pattern and sea ice extent, based on the using of observation data and the joint wavelet analysis PC programs complex "GeoMath".

Key words: micros computer technology "GeoMath", wavelet analysis , sensing corelation, teleconnection patterns, ice extent.

Резюме

ДЕТЕКТУВАННЯ КОРЕЛЯЦІЇ МІЖ АТМОСФЕРНИМИ ТЕЛЕКОННЕКЦІЙНИМИ ПАТТЕРНАМИ ТА ЛЬДОВИМИ УМОВАМИ: МІКРОС ТЕХНОЛОГІЯ "GEOMATH"

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Розроблено мікрос технологію обробки данних і детектування кореляції між атмосферними телеконнекційними паттернами та величиною морського льодового покриття, яка базується на використанні данних спостережень та ПК комплексу програм вейвлет аналізу "GeoMath".

Ключові слова: мікрос технологія "GeoMath", вейвлет аналіз, детектування кореляції, телеконнекційні паттерни, льодові умови.

Резюме

ДЕТЕКТИРОВАНИЕ КОРЕЛЛЯЦИИ МЕЖДУ АТМОСФЕРНЫМИ ТЕЛЕКОННЕКЦИОННЫМИ ПАТТЕРНАМИ И ЛЕДОВЫМИ УСЛОВИЯМИ: МИКРОС ТЕХНОЛОГИЯ "GEOMATH"

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Разработана микрос технология обработки данных и детектирования корелляции между атмосферными телеконнекционными паттернами и величиной морского ледового покрития, базирующаяся на использовании данных наблюдений и ПК комплексе программ вэйвлет анализа "GeoMath".

Ключевые слова: микрос технология "GeoMath", вэйвлет анализ, детектирование корелляции, телеконнекционные паттерны, ледовые условия.

Carrying out new, avanced sensors and microsystems technologies in the modern atmosphere and environmental physics is related to ine of the most important problems (c.f.[1-14]). Here we present an advanced micros data processing technology for the correlation between atmospheric teleconnection patterns and sea ice extent, based on the using of observation data and the joint wavelet analysis PC programs complex "GeoMath" [1-3].

Let us note that the climate model projections of a future climate change due to increased greenhouse gas concentrations show a maximum annual mean warming near the surface in the high northern latitudes. This warming is aligned with a retreat of sea ice. Numerical experiments, which were performed by Hilmer and Lemke (2000) [9], show that a net reduction of Arctic sea ice volume amounts to the 4% per decade for the period starting with the 1961, the decrease within the 1987-1998 was three to six times larger than within the previous periods. Some sensitivity experiments with a sophisticated sea ice model have revealed that the sea ice cover is most strongly affected by the surface air temperature and the surface wind field whereas other forcing parameters play a minor role. On the other hand, both aforementioned parameters are strongly affected by the atmospheric teleconnection patterns. The Arctic Oscillation, the North Atlantic Oscillation (NAO), and the Pacific/North American (PNA) can be considered as the dominant atmospheric modes of variability in the Arctic. The joint analysis for the variability of atmospheric circulation and sea ice extent (SI) in the Arctic seems as attractive but for the case of observational time series there are some difficulties. First from theirs consists in the comparatively short monthly time series of ice conditions for most seas in the Arctic basin since reliable data appeared at the satellite era. Other difficulty lies in the fact that the SI is characterized by pronounced annual variations with the summer minima and the winter maxima. Against these variations the low-frequency atmospheric influence is hard evolved. In this paper, to reveal the atmospheric forcing of the SI in some Arctic seas we use approach based on the wavelet decomposition which allows to solve some questions by extracting the common characteristics of variability in the time frequency space. This method was successfully applied to many geophysical signals, including the time series of atmospheric teleconnection patterns and sea ice (c.f.[1-3,5,8,11]).

Regarding the method and data let us consider only the key features. Main approach used in the current study is cross wavelet transform which was in detail described in [1-3,8]. Wavelets are the fundamental building block functions, analogous to the trigonometric sine and cosine functions. The particular wavelet can be characterized by how it is localized in time and frequency (for details see [4]). When using wavelets for feature extraction purposes the Morlet wavelet is a good choice, since it provides a good balance between time and frequency localization.

The idea behind the continuous wavelet transform (CWT) is to apply the wavelet as a bandpass filter to the time series. The wavelet is stretched in time by varying its scale and normalizing it to have unit energy. The continuous wavelet transform of a time series with uniform time step is defined as the convolution of this series with the scaled and normalized wavelet. The cross wavelet transform of two time series is defined as complex conjugation of two particular continuous wavelet transform. This approach allows to define the cross wavelet power (CWP) and the local relative phase (LRP) between two tome series in time frequency domain.

Here, we consider monthly indices for the the North Atlantic Oscillation NAO and the the Pacific/North American PNA as well as the monthly ice extents in the Bering Sea, the Baffin Bay, the Greenland Sea, and the Kara-Barents seas from November 1978 to December 2002. The sea ice extent dataset is derived from brightness temperatures by the bootstrap algorithm (Comiso, 2002). Except for the Bering Sea, which is ice-free during August, other seas are ice-covered during all seasons. It is naturally that sea ice conditions in the Bering Sea are affected by the the Pacific/North American PNA rather than the the North Atlantic Oscillation NAO whereas for other three seas the influence of the the North Atlantic Oscillation NAO should be dominant. The choice for the three seas in the Atlantic sector is conditioned by the different trends in the ice thickness during the last decades of twenty century (c.f.[10]). We standardize all time series and, since the monthly sea ice extent is far from normally distributed, transform indices for the SIs into a record of percentiles (in terms of its cumulative distribution function).

It is naturally that for the case of two particular seas the cross wavelet power with the 5% significance level has maxima in the 8-16 month band which are caused by the annual variations of the SI. On the other hand, in such time band the local relative phases of sea ice extent in the Atlantic basin lead slightly that in the Bering Sea. Figure 1 showing the cross wavelet power and local relative phase of SIs in the Bering Sea and the Greenland Sea can be considered as the example of such behaviour. Also, the comparatively large the cross wavelet power outside the 5% significance level is registered for these seas only.

Other interesting feature of cross wavelet relationship in Fig. 1 is the fact that on the time scale with the 3-4-year period the local relative phase is anti-phase. Moreover, the 3-4 year band is characterized by the significant wavelet coherence calculated as proposed by Torrence and Compo in ref.[13]. To a certain extent, this behaviour can be analogous to the Antarctic Dipole in the Southern Ocean (c.f.[10,12]) though the cross wavelet power is not significant.

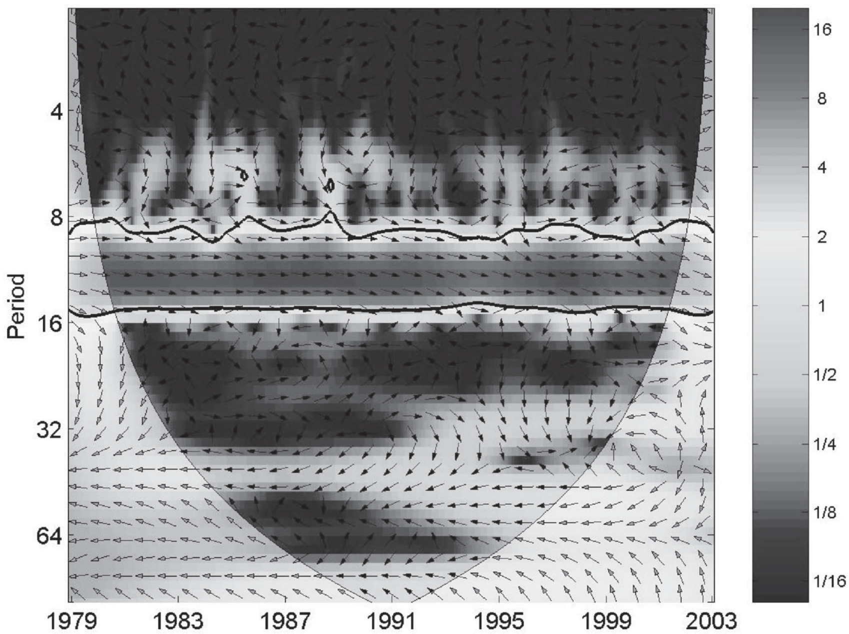

Figure 1. The cross wavelet power of the SIs time series in the Bering Sea (BSI) and the Greenland Sea (GSI). The the 5% significance level against red noise is shown as a thick contour and cone of influence where edge effects might distort the picture is shown as a lighter shade. The the local relative phase LRP is shown as arrows (with in-phase pointing right, anti-phase pointing left, and GSI leading BSI by 90є pointing straight down).

In conclusion let us present the key summary. We use wavelet analysis within the "GeoMath" technology to reveal coherence in the variability of atmospheric circulation and ice conditions in the Arctic seas. This analysis allows decomposing time series as well as estimating common wavelet power. Using the cross wavelet power we uncovered that there is the significant anti-phase relationship between the ice extent in the Bering and the Greenland seas. To a certain extent, this relationship can be analogous to the Antarctic Dipole in the Southern Ocean. So, our micros data processing "GeoMath" technology allows sensing the sensing the correlation between atmospheric teleconnection pattern and sea ice extent and can be considered as quite powerful and effective tool in studying complex geosystems.

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