Trends in circulation indices extremes in reanalysis data and seasonal hindcast integrations

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Building on the methods and results of the previous contribution (*Muravev et al, 2007*), which focused on five circulation indices (*Wallace, and Gutzler, 1981*) calculated for daily values, the interannual variability of the circulation indices extremes within the summer and winter seasons is investigated.

Initial information is gained from the following sources: the NCEP/NCAR reanalysis for the two seasons from 1983-2002/2003, and hindcast integrations of global spectral T41L15 GCM. Integrations were performed for 90 days starting from dates 31.06 and 30.11, the SSTs were taken and preprocessed as reanalysis daily values from the same year interval. Thus, the extreme value predictability is assessed as a potential one.

A daily climate and standard deviations have been calculated on the basis of 500 hPa reanalysis and model heights for the given year period. The circulation indices were calculated as normalized daily deviations from the daily climate. The intra-seasonal index characteristics were obtained for the two data types. Examples of circulation indices for the Northern Atlantic region are given in **Figure**.

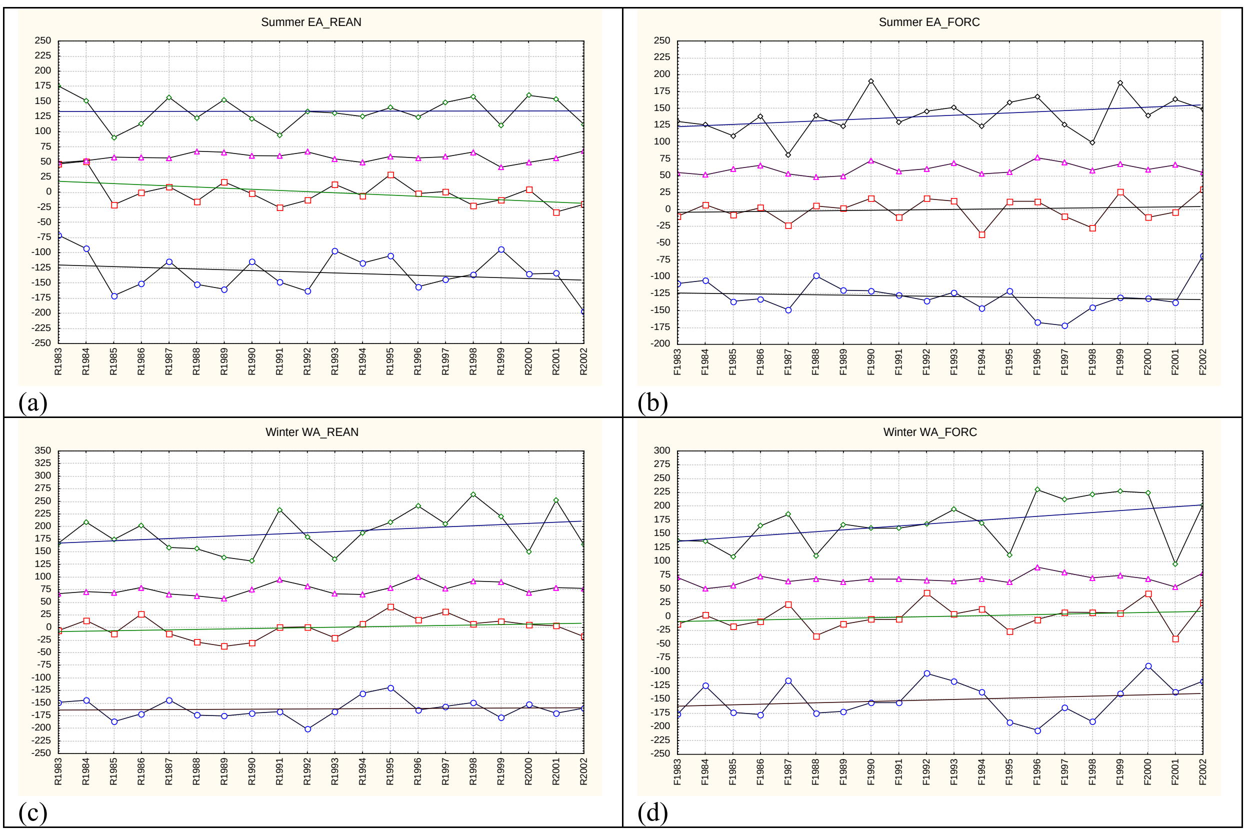

Figure. Interannual variations of characteristics of EA and WA indices (×100). The left panel contains the reanalysis data indices, the right panel carries the model data indices. Indices are as follows: summer EA (a, b), winter WA (c, в). Every panel contains, from top to bottom, curves for the following characteristics: maximum, standard deviation, mean and minimum index values within the season of the given year. Straight lines demonstrate linear trends.

The analysis of all curves yields the following conclusions. First, the variability assessed using the standard deviation is reproduced rather satisfactorily. Second, the linear trends in the mean index values are either small or caused by sampling effects due to single outliers. Third, the minimum and maximum index values evidently point to the main variability over the year period.

Statistical significance of all calculated trends (at the rate of 60 = 2 seasons × 2 data types × 5 indices × 3 curves) is assessed with the help of the nonparametric inversions test (*Bendat, and Piersol, 1986*). The results for all circulation indices are accumulated in **Table**.

Table

Inversions number for characteristics of modeled and reanalysis index values for the 1983-2002/03 period. Letters m, r denote the model and reanalysis data indices, respectively.

	EA_m	EA_r	EU_m	EU_r	PNA_m	PNA_r	WA_m	WA_r	WP_m	WP_r
WINTER										
Mean	97	85	89	94	93	81	68	66	78	89
Minimum	110	109	76	86	91	100	75	78	89	112
Maximum	72	86	90	103	88	84	**50**	**63**	91	86
SUMMER										
Mean	87	105	90	99	100	110	89	110	120	95
Minimum	115	83	73	72	92	102	98	84	92	89
Maximum	**61**	74	97	79	83	96	78	112	117	94

The three significant trends at the 95% confidence level stand out as relevant, defined by breaking out the [64,125] interval and depicted in bold in **Table**. Two of them are the maximum winter WA values for reanalysis (Fig.c), and for model data (Fig. d). The third case relates to the summer EA calculated for the model data (Fig.b). Thus, the model has reproduced the real maximum winter WA index values trend and generated a positive trend in the summer EA index not observed in reanalysis. These are the two key signals for the modeler and forecaster. Let us however highlight the fact that the no-trend hypothesis acceptance may lead to type II error, since some test values are close to critical test distribution areas.

The generation of the false trend in the summer EA index calls attention to the model blocks of the ocean-atmosphere interaction over the given geographical region of the Northern Hemisphere.

The reproduced linear trend in the maximum West-Atlantic circulation index (WA) gives a definite synoptic advantage. The trend signals of enhancement of the meridional circulation feature. This, in its turn, is expressed in the 500 hPa height trough deepening over the eastern North America and the storm-track shift towards Scandinavia. A similar shift of the cyclone activity zone towards the pole in the second part of the 20^{th} century has been observed, for instance, in (*Hurrell et al., 2003*). The synoptic consequence of such development in the atmospheric circulation may lie in high positive temperature anomalies over the Northern Europe, as well as over the Western Siberia and Central Asia.

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