Atmospheric Centers of Action in Northern Hemisphere from Observations and Simulations: Interannual Variability and Long-Term Tendencies of Change

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Interannual and long-term changes of Atmospheric Centers of Action (CoAs) in the Northern Hemisphere (NH) are analyzed using different data sets based on observations (Catalogue, 1988; Jones, 1987; Kistler et al., 2001) and global climate model simulations with anthropogenic IPCC scenarios, including coupled general circulation models ECHAM4/OPYC3 (Oberhuber, 1993; Roeckner et al., 1996), HadCM3 (Collins et al., 2001) and IAP RAS climate model (CM) of intermediate complexity (Petoukhov et al., 1998; Mokhov et al., 2002). Tendencies of change of CoAs are estimated with use of temperature data from (Jones and Moberg, 2003). Special attention is paid to winter seasons with the largest temperature changes near surface.

Sensitivity of the CoAs characteristics to the change of the NH surface air temperature (T_{NH}) can be estimated by coefficients of appropriate linear regressions. Table 1 presents coefficients of regression of CoAs characteristics to the T_{NH} variations in winter for the period 1949-2000. All analyzed data show intensification of Aleutian Low and both North Atlantic CoAs during the second half of the XX century. Tendencies of change of the Siberian High intensity from different data sets are quite contradictory.

Aleutian Low and Hawaiian High display statistically significant relationship to the El-Nino/La-Nina phenomena with intensification of this relationship to the end of the XX century. Aleutian Low deepens (weakens) and shifts eastward (westward) and Hawaiian High weakens (strengthens) and shifts southward (northward) during the El-Nino (La-Nina) events. Results of wavelet analysis exhibit the intensification of the El-Nino/La-Nina related variations (with periods about 4–6 years) of Aleutian Low and Hawaiian High at the end of the XX century.

Global climate models show an ability to simulate not just mean regimes of CoAs but also their dynamics. In particular, ECHAM4/OPYC3 simulations reproduce the relationship between North Pacific CoAs and the El-Nino/La-Nina phenomena and its intensification at the end of the XX century (Fig.1). According to these simulations the strongest correlation between North Pacific CoAs and El-Nino/La-Nina phenomena is found at the end of XX century and at the beginning of XXI century. The ECHAM4/OPYC3 model shows the intensification of Aleutian and Islandic Lows while weakening of Siberian High to the end of the XXI century with respect to the end of the XX century. The IAP RAS CM also shows the intensification of Aleutian Low and weakening of Siberian High with changes larger than for the ECHAM4/OPYC3. More significant differences are obtained for Islandic Low.

Qualitative analysis of obtained results is performed with the use of relatively simple model for the CoA characteristics proposed by Mokhov and Petoukhov (2000). According to this analytical model the long-term changes of Aleutian and Islandic Lows are related to the weakening of tropospheric static stability under warming. Significant interannual variations of Aleutian Low (related to the El-Nino/La-Nina phenomena) are in agreement with the appropriate variations of zonal wind in the troposphere. The relationship of longitudinal shift between the winter pressure maximum and cold weather center in Siberia with the El-Nino phenomenon is also interpretated on the basis of this model.

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Table 1. Coefficients of linear regressions of CoAs characteristics (central pressure P_C, longitude λ_C, and latitude φ_C) to the T_{NH} variations for winters during the period 1949-2000. (Values with ** and * are significant at the 95% and 90% confidence levels).

Data	Azores High	Icelandic Low	Siberian High	Aleutian Low	Hawaiian High	Canadian High
dP_C/dT_{NH} [hPa/K]						
NCEP/NCAR (Kistler e.a., 2001)	3.4 **	-4.2	-0.1	-5.5 **	-1.3	0.5
CRU (Jones, 1987)	3.4 **	-4.4	-5.7 *	-6.0 **	-1.3	-1.7
VNIIGMI (Catalogue, 1988)	4.8 **	-5.8 *	5.3	-7.1 **	-1.0	-1.6
$d\lambda_C/dT_{NH}$ [deg./K]						
NCEP/NCAR (Kistler e.a., 2001)	3.0	6.8	-1.5	17.1 *	4.2	-2.1
CRU (Jones, 1987)	7.0	9.0	-6.9 *	11.8	5.1 *	15.2
VNIIGMI (Catalogue, 1988)	7.7	3.3	-2.7	5.0	-1.2	-6.6
$d\varphi_C/dT_{NH}$ [deg./K]						
NCEP/NCAR (Kistler e.a., 2001)	0.4	2.5	0.5	-0.2	-3.4 *	-2.0
CRU (Jones, 1987)	1.9	4.1	-3.3 *	-0.8	-2.7 *	-9.3
VNIIGMI (Catalogue, 1988)	1.5	2.9	-4.3 *	1.5	-2.1	0.3

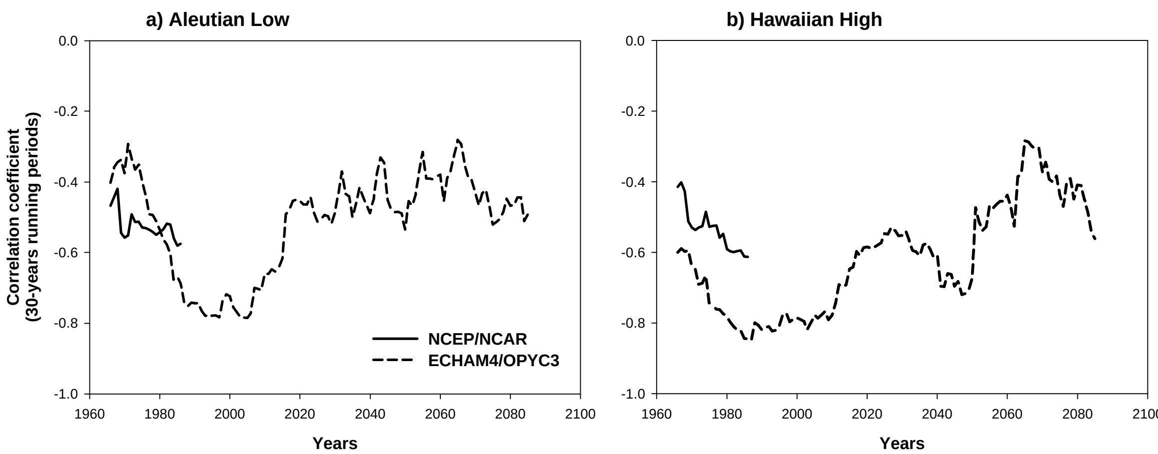

Figure 1 Coefficients of correlation between Nino3 SST and intensity of Aleutian Low (a) and Hawaiian High (b) in winter for 30-years running periods for NCEP/NCAR data and ECHAM4/OPYC3 model.