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The effect of some dynamic processes on the variability and anomaly behavior of minor atmospheric components under high-mountain conditions

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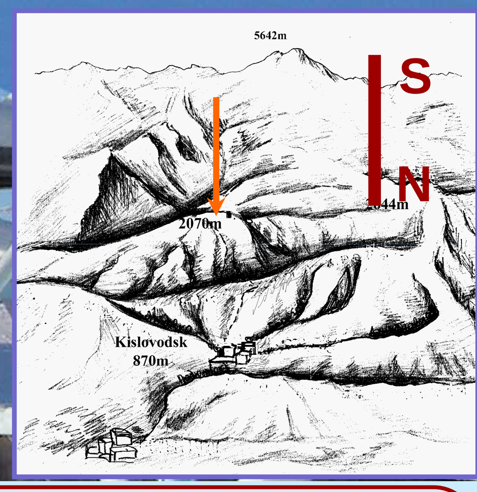


KHMS

Kislovodsk high-mountain station

of Obukhov Institute of Atmospheric physics Russia Academy of Science (KHMS)

Station specification

KHMS (43.7°N, 42.7°E; 2070 m asl) is located 48 km to the north of Elbrus (5642 m) in alpine grasslands of the Shadzhatmaz plateau at the northern slanting slope of the Caucasian Ridge extended in the latitudinal direction. The mountain and valley winds are much less pronounced than that in the regions with steep slopes . Southerly winds (down slop) are here most frequent in the course of year. The valley wind is less regular and is characterized by a rather low speed.Regional station of GAW WMO "KIS" and Station #282, www.khms.ru

Abstract

The results of an analysis of some features and anomalies of behavior of key parameters of surface air at the Kislovodsk high-mountain station (KHMS, 2070 m a.s.l., the Northern Caucasus, Russia) are presented.

Introduction

Mountain stations play a special role in the system of atmospheric monitoring because of their localization above the planetary boundary layer (PBL). The data of these stations reflects background regional and even global conditions of the free troposphere. However, the well-known dynamic factors, such as uphill–downhill circulation and lifting effect, can activate the air exchange between the atmospheric boundary layer (ABL) and the free troposphere in station vicinities. To segregate the background data important for climatic and ecological estimations from the totality of observational data, these processes should be taken into account individually for each station.

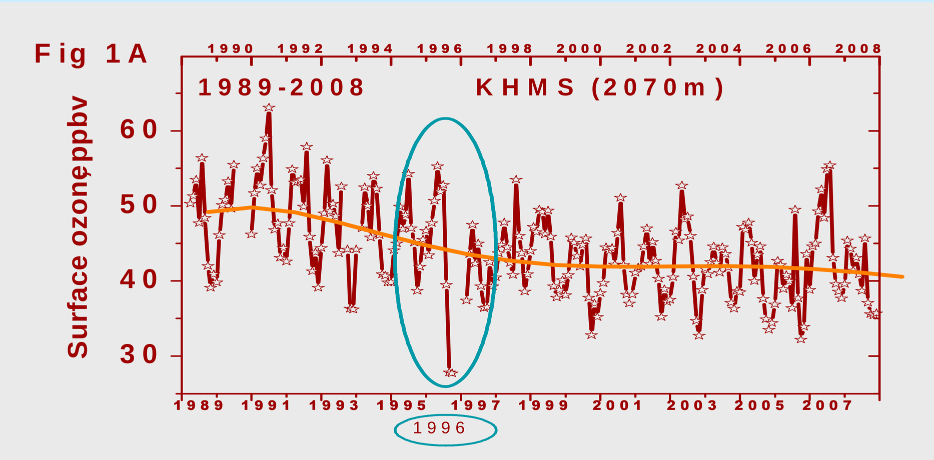
Objective. Prolongation of researches of natural and anthropogenic factors in the next period (after 2000) became necessary because of observed some weather anomalies and some strangeness and peculiarities in the behavior of surface ozone concentration.
Studies of the effect of large-scale and local dynamic processes on the formation of surface ozone level were carried out to reveal the cause of huge negative anomaly in the surface ozone concentration observed at the KHMS in 1996 and of a decrease in the magnitude of its negative trend (by a factor of more than two) since 1996.

Procedure of evaluation of the effect of urban pollutants on the situation at the KHMS has been carried out in 2001.

Results

- **It has been stated that the uphill–downhill circulation in the KHMS region develops weakly.**
- **The KHMS atmosphere is influenced by pollutants from the PBL only slightly in the separate synoptic and ecological situations well-known and described. For example, large-scale regional fires, advections from the polluted areas, special synoptic conditions.. [Senik et al., 2004, 2005].**

The analysis of the possible reasons of anomalies surface osone at KHMS and JFJ



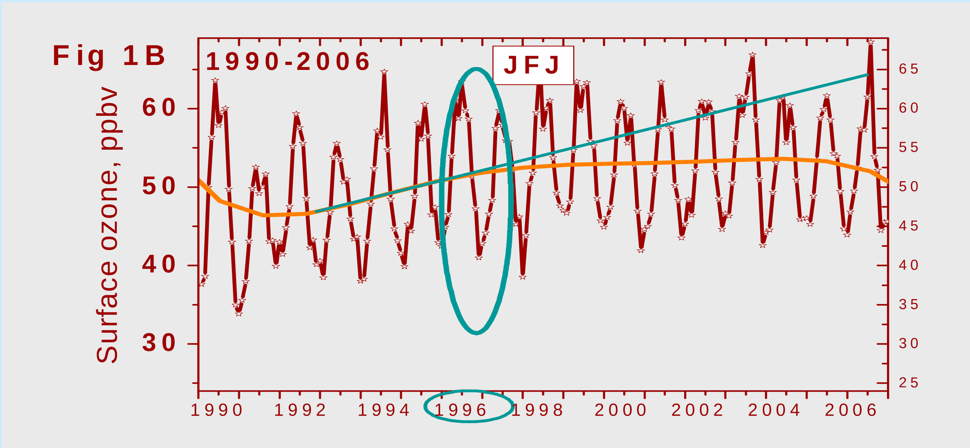


Figure 1 A,B Monthly average values of the surface ozone concentration at the KHMS (04.1989-12.2008), JFJ (1990-2006) and Polynomial (4 and 5 degrees) fitting

The ozone series was subjected to spectral analysis. Local Wavelet analysis allowed distinguish that the point relating to 1996 is a particular point (in the plot of fig.1A, it is an excess point). This moment perhaps is connected with the large-scale reorganization of an atmospheric dynamic regime and with the changes in character of behave of the small species. It was confirmed by the analysis of indexes of global circulation and the analysis of a wind regime at KHMS

The analysis quasi-periodi periodic structures

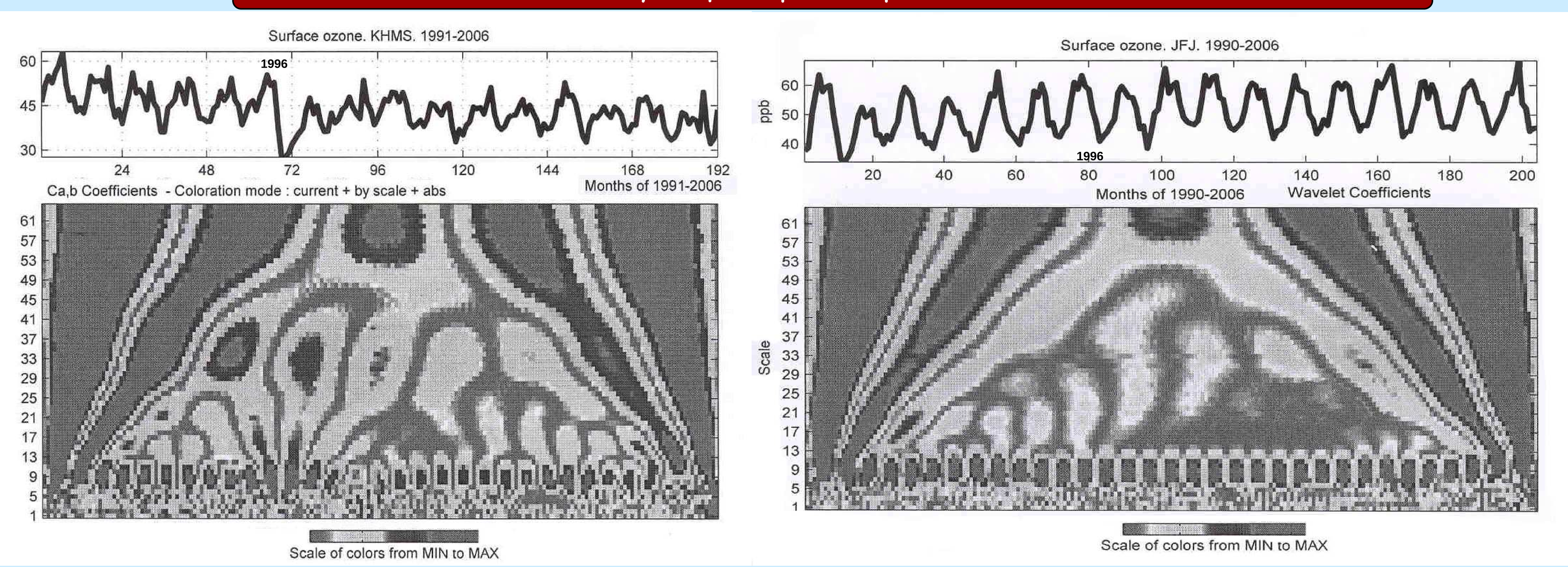


Figure 2A,B. Time-scale spectrum of the Wavelet (Morlet) transform coefficients for the ozone mixing ratio sets obtained at the KHMS (1991-2006) and JFJ (1990-2006).

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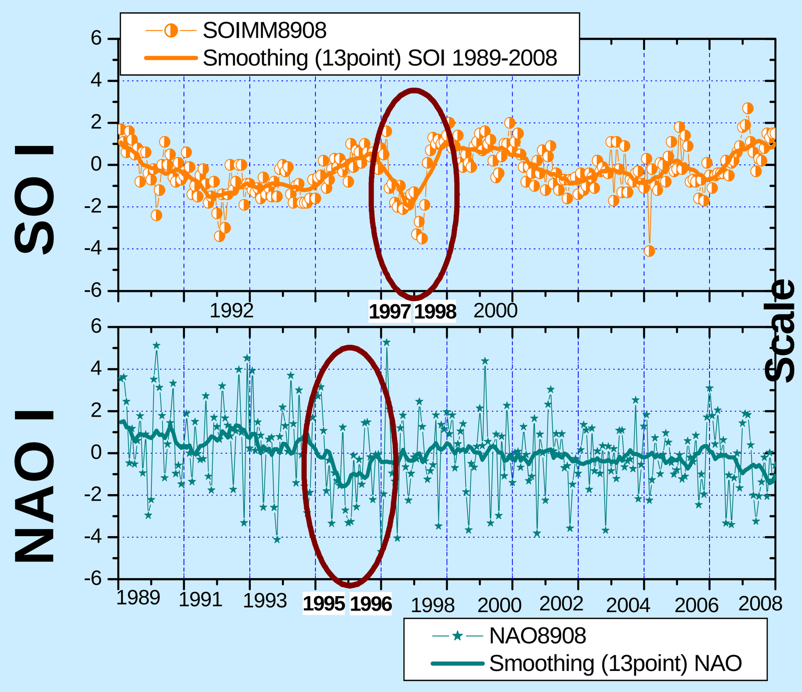
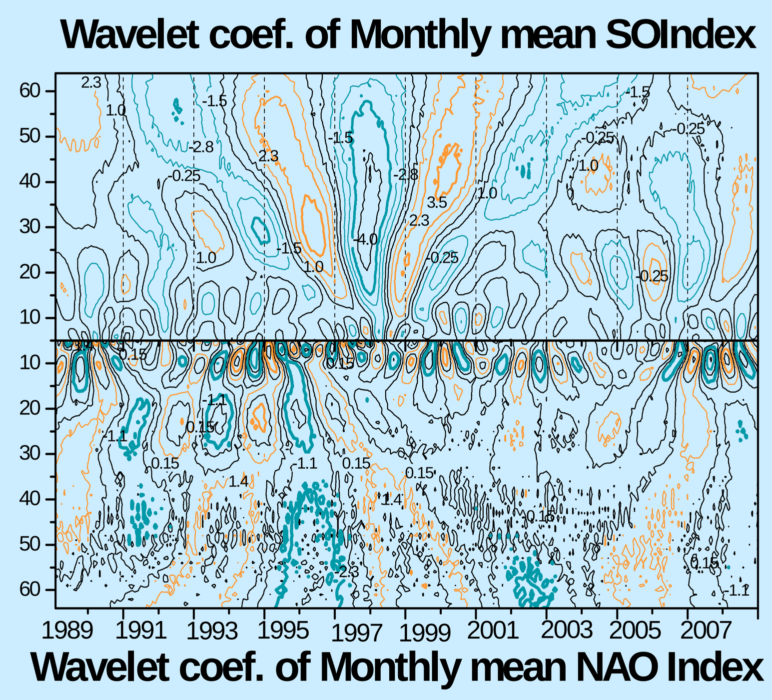
It was confirmed by the analysis of indexes of global circulation and the analysis of a wind regime at KHMSThe time-scale spectrum of the Wavelet transform of the ozone series obtained at the KHMS is presented in the lower panel of fig 2A. Scale 1-61 corresponds to the periods of 0.1-6.1-year oscillations. The pictures of the Wavelet transformation coefficients show a quasi-periodical structures on the scales corresponding to periods of 1, 1.5, 3.5 years during 1991–1996/1997. Periods of 1.5 of 3.5 years correspond to the oscillations with combined frequencies of an annual cycle with 2-year and 2.5-year fluctuations, which are associated with QBO of speed of a zonal equatorial stratospheric wind (Gruzdev et.al., 1999). By the end of 1996, the situation transformed: short (1-year and 1.5-year) fluctuations were blocked, and even 3.5-year fluctuations weakened.
Further dynamic processes increased their energy contributions, the annual cycle was restored, 4-year fluctuations gradually appeared and late 3-years and 2-years were observed. Thus, the regime of long-range variations in ozone changed.
The amazing coordination of the long-term ozone variability observed at the KHMS with that observed at the Jungfraujoch high-mountain station in Switzerland ((JFJ, 46.55oN, 7.98oE, 3580 m a.s.l.) was found in the framework of the Joint Research Project SCOPES found Swiss National Science Foundation (SNFW) (**O. A**. Tarasova, I. A. Senik, M. G. Sosonkin, J. Cui, J. Staehelin, and A. S. H. Prévôt, 2009). In the diagram of the surface ozone concentration observed at the JFJ in 1996/1997, the excess point is noticeable too and, though a trend at the JFJ was positive, growth was slowed down.
The Wavelet specter, constructed for the JFJ data, confirms a large scale and uniformity of reorganization of the atmospheric dynamics in 1996/1997: the presence of QBO till 1996/1997 and blocking of short-period fluctuations and drift of frequency after that. Wavelet analysis of long-term measurements of surface ozone at the KHMS confirms changes in the atmospheric circulation regime in the late 1990s and possible association of this process with synchronous changes in the trend observed at the KHMS and JFJ stations.

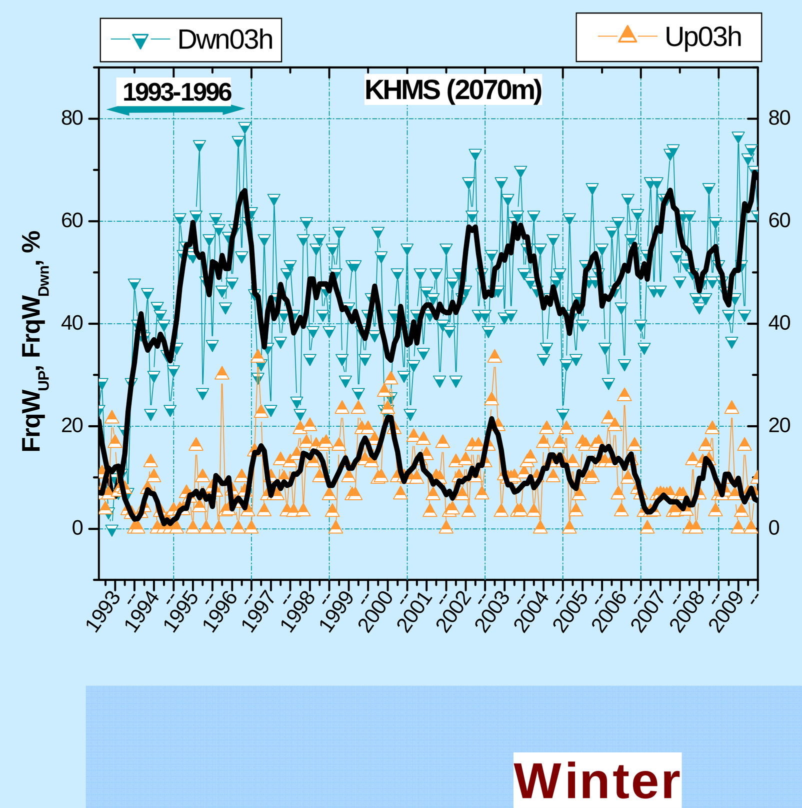
Application Wavelet transformation for analysis of circulation indexes NAO and SOI



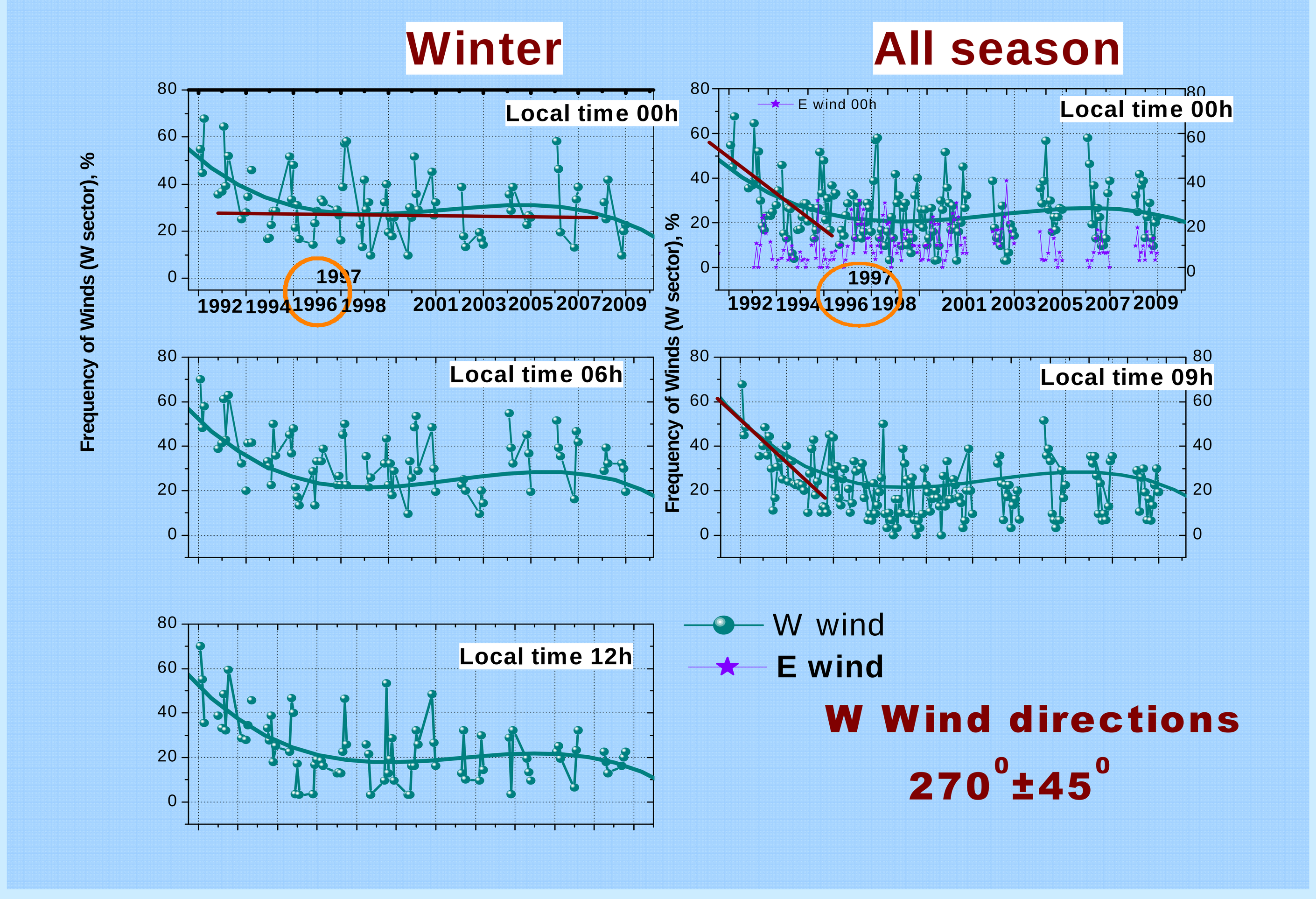


To evaluate the role of different factors defining the inter-annual variability of the surface ozone at two elevated sites, the following set of diagnostic parameters was considered:
1) global factors
the Southern Oscillation – SOI index (Tahiti –Darwin Sea Level Pressure ANOMALY)
North Atlantic Oscillation – NAO index
Winds of W and E sectors – characteristic of zonal circulation
Winds of N and S directions correspond with meridian circulation
2) local factors
N - Uphill wind in framework of local mountain-valley circulation (
S – Downhill wind in framework of local mountain-valley circulation

Local wind



Monthly mean frequency (%) of surface winds registered at KHMS for 4 main sectors W,E,N,S (Δ =90) were analyzed. In the plots and pictures of the coefficients of Wavelet transformations special points are revealed as a point kink or as peculiarity on type of shift phase, or as a beginning change of frequency. For SO Index it is point 1995, for NAO – earlier, 1996. The regime of a surface wind confirms, that zonal circulation is blocked and weakens, meridian circulation is strongest.



Summary

- Southerly winds are here most frequent in the course of year. The valley (from N) wind (in framework of local uphill–downhill atmospheric circulation) is less regular and is characterized by a rather low speed.
- Wavelet analysis of the indexes of global atmospheric circulation and long-term measurements of surface ozone at the KHMS and JFJ confirms changes in the atmospheric circulation regime in the late 1990s and possible association of this process with synchronous changes in the trend observed at the KHMS and JFJ stations.
- The measurements at the KHMS, due to its remoteness from pollution sources and local peculiarities causing the low level and weak variability of the SOC, may be used for understanding the effects of large-scale circulation of atmosphere and for estimations of the role of transboundary transport in the formation of ozone-field of the middle troposphere.

An analysis of the interannual variability of the seasonal characteristics shows that the large-scale circulation of the tropical atmosphere modulates not only the SOC at the KHMS but also the phase of its seasonal cycle (see Tab.*) [Senik I.A., Elansky N.F., Pankratova N.V., and Moeseenko K.B. Proc. XX Quadrennial Ozone Symposium, Ed. Christos S. Zerefos, Vol. 2, 2004, p. 911-912]

References, Acknowledgements

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