Mutual dynamics of atmospheric components and climatic characteristics during last 420,000 years from Vostok ice core

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Mutual dynamics of climatic characteristics and atmospheric components from the Antarctic ice core at the Vostok station during last 420,000 years (Petit et al., 1999; Kotlyakov and Lorius, 2000) with the 500-years temporal resolution is analyzed. Time series of the deuterium content of the ice (T), the greenhouse gases carbon dioxide (C) and methane (M) contents, the oxygen 18 content (I), the dust content (Ac), and the concentration of sodium (Am) are studied with the use of correlation analysis - CA, spectral analysis - SA, wavelet analysis - WA, (Morlet, 1983; Farge, 1992) and cross wavelet analysis - CWA, (Bezverknny, 2001). For the mutual analysis of two time series the characteristics are introduced similar to cross spectral ones. Local phase lag, coherence and correlation of two time series based on their wavelet transforms are defined.

The deuterium content of the ice is a characteristic of temperature (Petit et al., 1999), while the oxygen 18 content variations reflect changes in global ice volume and in hydrological cycle (Bender et al., 1994). The dust and sodium contents characterize the continental and marine aerosol concentrations, respectively.

The results of SA for T, C, M, I, Ac and Am display maxima at Milankovitch periods (19, 23, 41 and 100 kyrs), MPs (Petit et al., 1999). As an example Fig.1 shows results of WA for I. These maxima are significant at the level of “red noise” but not all of them, except for T and C, are significant at the level of 95%. Especially for Ac all of them are not significant at the 95% level. The only MP peak insignificant at the 95% level for I is the 100-kyr peak, but for Am it is on the opposite the only significant one at such a level. For M similar level of significance was obtained only at periods near 20 kyr. More detailed results of WA show remarkable amplitude variations for all analyzed variables near MPs.

Results of CA show the best correlation with delay of C, M and I relative to T, Ac and Am. For instance, the best correlation between T and C data sets was obtained with a 1 kyr delay of C relative T. (It is in a general agreement with results of previous analysis. In particular, from the analysis of the last three glacial terminations Fisher et al. (1999) found that the C changes 600±400 years after the T changes.) The I lags as a whole with respect to other variables.

Results of CWA display phase lags at MP for different variables. In particular, the C and I changes are generally delayed with respect to the T changes (with delay up to several kyrs) at all MP. The mutual M-T, Ac-T and Am-T amplitude and phase dynamics are more complicated with differences at various MP.

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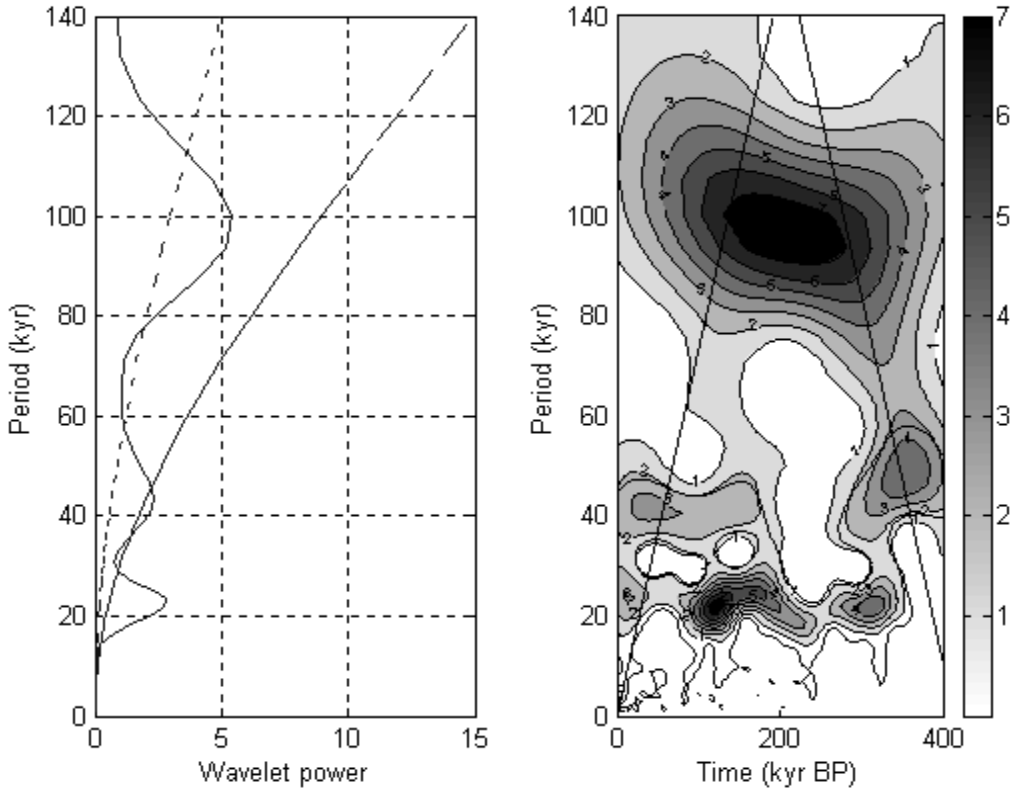

Figure 1. Wavelet analysis of I (oxygen 18 content, in $^{o}/_{oo}$) during last 420,000 years.

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