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Holocene ^{14}C production rate and solar activity

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Abstract. We have used most recent archaeomagnetic and ice core CO_2 records for the long-term trend correction in global tree ring radiocarbon concentration ($\Delta^{14}C$). The short-term CO_2 exchange system was approximated via first order differential equation with frequency dependent coefficients. A generalized multi-scale box model was constructed and used for the reservoir effect correction.

1. Introduction

It is known that ^{14}C produced from atmospheric nitrogen after the chain of nuclear reactions induced by galactic cosmic ray fluxes. Both terrestrial magnetic moment and partly atmospheric CO_2 changes are the causes of measured atmospheric $^{14}C/^{12}C$ long-term variation during the Holocene. Moreover, CO_2 reservoir exchange leads to shift and decay of short term atmospheric variations of ^{14}C concentration in the range of periods 10-1000 yrs.

2. Method and results

Long-term changes of the initial ^{14}C curve are corrected using recent compilation by Yang *et al.* (2000) of the archaeomagnetic data and Elsasser *et al.* (1956) relation. CO_2 record of Tailor Dome by Indermuehle *et al.* (1999) and Law Dome ice core by Etheridge *et al.* (1996) was used to get the long-term variation of $\delta^{14}C$ value by Stuiver *et al.* (1977). This value was used as input $n(t,\omega)$ to our generalized multi-scale box model in the following form:

$$C_1(\omega)dn(t,\omega)/dt + C_2(\omega)n(t,\omega) = S(t,\omega). \tag{2.1}$$

Here $n(t,\omega)$ - frequency and time dependent absolute atmospheric radiocarbon concentration, $S(t,\omega)$ - radiocarbon source (galactic cosmic ray flux modulated by solar activity). This equation describes the multi-scale reservoir shifts and decay (including radioactive one) in most general form. Using direct wavelet transform we approximated C_1 and C_2 in least square sense for the known (calibration) time interval. Then, using the inverse wavelet transform we estimated $S(t,\omega)$ for the preceding time.

Decadal radiocarbon Stuiver *et al.* (1998(2)) series was calibrated on the base of Wolf number set extension 1090-1950 by Nagovitsyn (1997). Obtained $S(t,\omega)$ estimation (figure 1) can be compared with the processing of naked eye sunspot observations (Nagovitsyn, 2001).

The annual radiocarbon series (Stuiver *et al.* 1998(1)) was calibrated on the base of Group sunspot numbers (GSN) by Hoyt & Schatten, 1998 and Zurich Wolf numbers

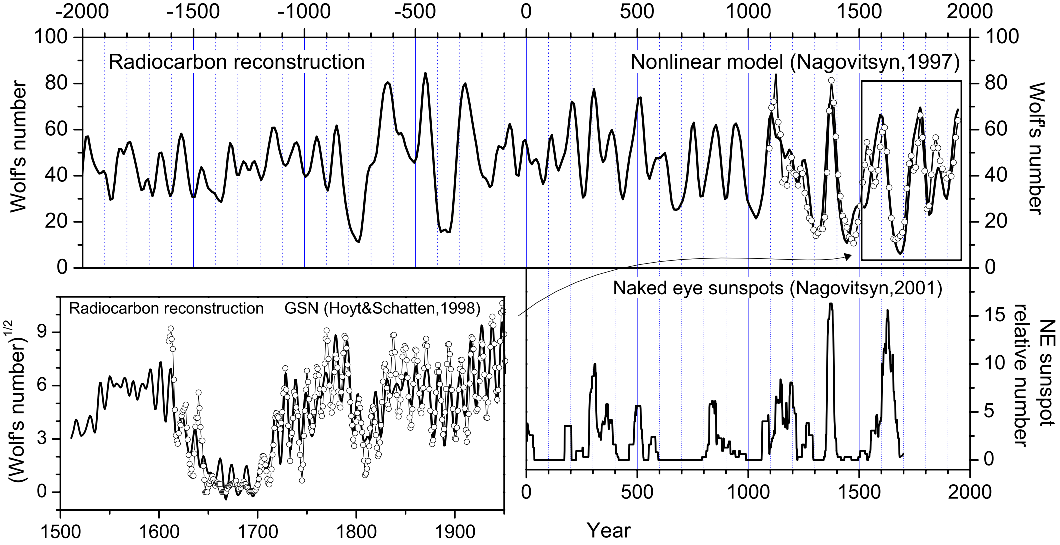

Figure 1. Annual and decadal solar activity based on radiocarbon production series.

through 1700-1950. Radiocarbon reconstruction $S(t, \omega)$ was estimated via average C_1, C_2 as shown in figure 1, bottom left panel. Correlation $S(t, \omega)$ with GSN during (1610-1950) yrs R=0.9. The fine structure of Maunder minimum epoch shows that none of 11-yr-cycles was lost in variations of radiocarbon reconstruction. These cycles have extra small amplitude and more long period (12-15) yrs.

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