Coherence between solar activity and the East Asian winter monsoon variability in the past 8000 years from sediment of the East China Sea

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Abstract

AMS^{14}C dating and grain-size analysis for Core PC-6, located on the inner shelf of East China Sea (ECS), was carried out for rebuilding records of the Holocene East Aaian Winter Monsoon. The core recorded the history of environment changes during postglacial transgression. The core's mud section above 450 cm is mainly carried by the ECS Winter Coastal Current (ECSWCC) with suspended mechanics during recent 7.6 ka. Two grain-size populations with the division at about 28um from Core PC-6 were verified by using a mathematic method called grain-size vs. standard deviation. The fine population (<28um) is considered as the product of the ECSWCC. Content of fine population in mud sedtion changes little and represents stable sedimentary environment in accord with the present which is dominated by the coastal current. High-resolution proxy for the East Asian Winter Monsoon (EAWM) is established based on the suspended population' mean grain-size.

Times of mean grain-size augmenting abruptly are inferred to be cold periods during recent 8 ka, which may result from the strengthening EAWM. A direct comparison between the sunspots change and the mean grain-size of suspended population is carried out. The good correlation between them suggests that one of the primary controls on centennial- to decadal-scale changes of the EAWM during this time is variations of the sun irradiance. Spectral analyses of the mean grain-size time series of Core PC-6 show statistically significant periodicities centre on 2463, 1368, 128, 106, 100, 88-91, 76-78, 70-72 years. The EAWM and the East Asian Summer Monsoon (EASM) agree with each other well on these cycles, and the East Asian Monsoon (EAM) and the India Monsoon also share in concurrent cycles in Holocene, which are in accord with the changes of the sun irradiance.

Keywords: the solar irradiance; the East Asian Monsoon; Holocene; spectral analyses; the East China Sea; grain-size

1. Regional setting

With a sediment discharge of 4.8x108 t/a in history, huge amount of sediments have accumulated at the estuary and neighborhood of the Yangtze River (Milliman and Meade, 1983). The ECS Coastal Current (ECSCC) changes its flow path seasonally. It flows northward in summer owing to the southeast monsoon, and southward in winter owing to the prevailing north wind (Qin et al., 1987; Su, 2001) (Fig.1). The modern surface mud on the inner shelf of ECS, so called "ECS inner shelf mud", is mainly derived from suspended sediments from the Yangtze River, and transported southward by the winter coastal current (Sun et al., 2000; Milliman et al., 1989; Su et al., 1989; Gu et al., 1997; Guo et al., 1999; Hu et al., 2001; Xiao and Li, 2005; Xiao et al., 2005) (Fig.2). The winter ECSCC will flow more rapidly when the winter monsoon becomes stronger, which will result in coarser deposits.Vice versa. According to this phenomenon, we use the grain-size of cores from the coastal mud as a proxy to discuss changes of the EAWM in Holocene.

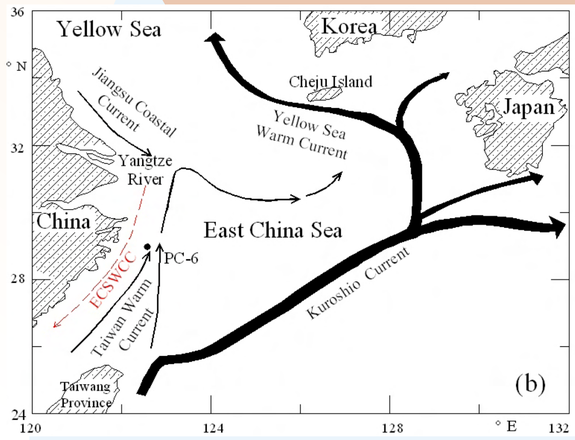

Fig. 1 The current systems of the ECS during winter times. Modified from Qin et

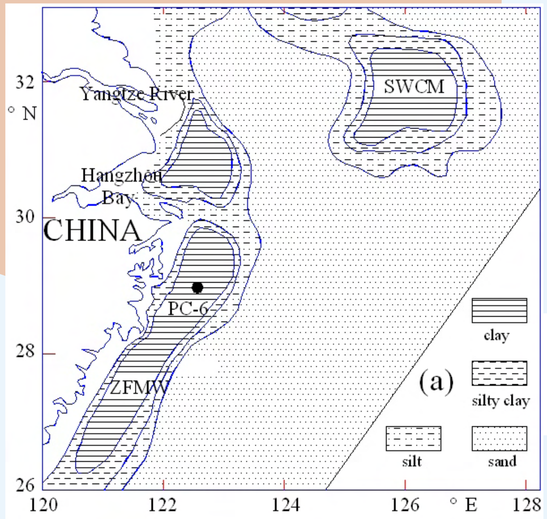

Fig.2 distribution of mud on the shelf of the ECS. Modified from Qin et al.(1987)

2. Materials and methods

Core PC-6 is 7.5 m, located in the mud area off Zhejiang province coast on the inner shelf of ECS, at water depth 56.7m, far away from any estuary (Fig. 1). Samples were pre-processed with excess H2O2 and HCl (3N) successively. Age dating was carried out at NOSAMS, Woods Hole Oceanographic Institution. All 14C ages have already been calibrated into calendar age with CALIB4.3 (Stuiver et al., 1998) .

3 Grain-size sensitive to sedimentary environments in Core PC-6

3.1 Lithology and sedimentary environment

The core is divided into 3 sections(Fig. 3). The lower section (540-750 cm), middle section (450-540 cm) and upper section (0-450 cm) belong to foreshore, nearshore and shallow sea repectively.

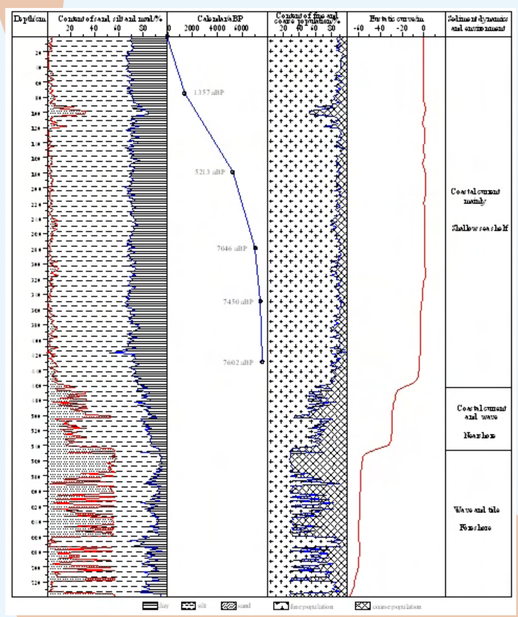

Fig. 3 Chronological strata and sediment dynamics of Core PC-6. The sea level curve is according to Liu et al.(2004)

The lower section was formed during high sea level period after transgression. No obvious event deposit is observed in this section excetp at ~100 cm. The fluctuation of sea level was about 3-4 m in the ECS since the last 7.6 ka (Liu et al., 2004). So, its sediment environment is relatively stable, and its sedimentary dynamics is the same as the present.

3.2 Grain-size sensitive to sedimentary environments

Each grain-size grade vs. their standard deviation of samples of Core PC-6 is calculated. Two populations are inferred with the division at about 28 um. The respective maximums, about 5.3 and 112 um, are grain-size sensitive to sedimentary environments. The former is sensitive to the coastal current, and the latter to wave.

Fig. 4. Shows contents of fine population in most samples of the upper section are more than 85% and change little, which also means stable sedimentary environment in accord with the present.In this paper, only mean grain-size of <28 um above 450 cm is adopted.

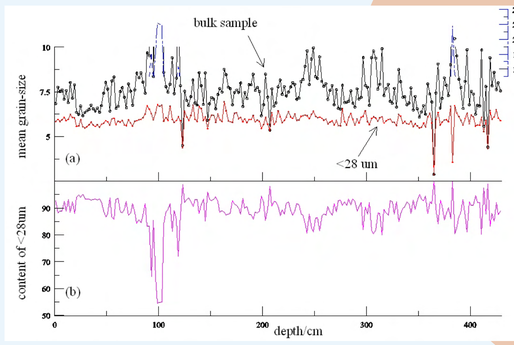

Fig. 4 Vertical variation of mean grain-size and content of fine population of Core PC-6

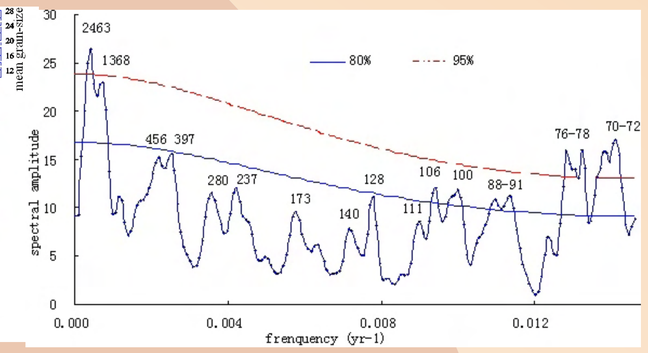

Fig. 5 Frequency analysis of Core PC-6 mean grain-size record for the entire samples. Parameters used are: nsim=1,500, n50=4, iWin=2 and others are defaulted. Red and blue lines are confident level 80% and 95% respectively.

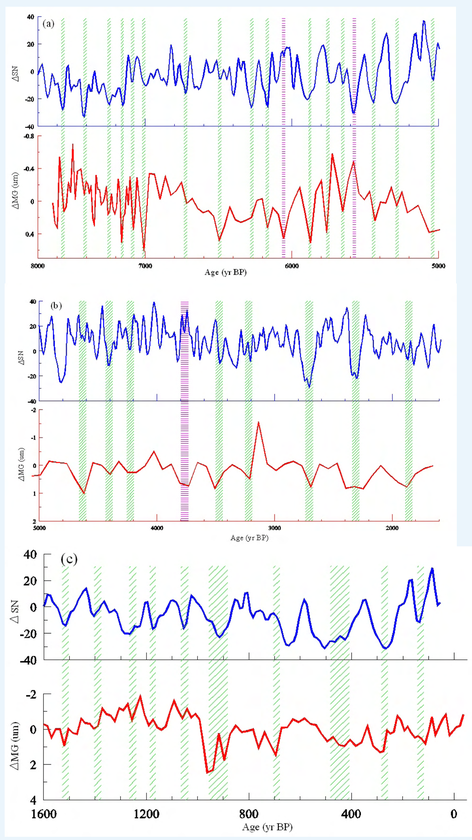

Fig. 6 Profiles of sunspot number and mean grain-size from Core PC-6 (a, b), DD2 (c). Owing to Core DD2's higher temporal resolution (about 16 a) than Core PC-6 after 1,600 yr BP, mean grain-size of the former is used as alternative in profile c.Sunspot number is reconstructed by Solanki et al. (2004) based on dendrochronologically dated radiocarbon concentrations (Stuiver et al., 1998).

4. Discussion

Spectral analyses of the grain-size record are given in Fig. 5. It shows statistically significant periodicities centre on 2463, 1368, 456, 397, 280, 237, 173, 140, 128, 111, 106, 100, 88-91, 76-78, 70-72 years. Most of these cycles are close to the periodicities of the tree-ring 14C record, which are assigned to solar modulation (Stuiver and Braziunas, 1999).

Fig. 6 shows big Mean Grain-size(MG) well corresponds to small SN except for two periods (marked in purple). This means the East Asian Winter Monsoon will increase when the sunspot number reduce. The intensity of the Indian monsoon is found to have decreased during periods of solar minima during the last millennium (Agnihotri et al., 2002). The similarity between the MG and SN time series is very strong, especially in high-resolution interval after ~1,600 yr BP and before 5,000 yr BP. The high correlation provides solid evidence that inner relationship exists between the East Asian Winter Monsoon and the sun irradiance.

5. Conclusions

The EAWM, the EASM and the India Monsoon share in concurrent cycles during the Holocene, which are in accord with the changes of the sun irradiance. It can be concluded that the sun irradiance is one of the primary controls on centennial- to decadal-scale changes of them.

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References (Omitted)