

EGU2020-7285

<https://doi.org/10.5194/egusphere-egu2020-7285>

EGU General Assembly 2020

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## Holocene 6000-yr climate cycles in temperate and sub-tropical SST records – a cosmic ray connection?

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Temperature cycles with periods > 2000 yr, including peaks of order 6000 yr, has been reported in <sup>14</sup>C proxy records in sediments for Fennoscandia (Olsen et al, 2005) and in glacier geochemistry for the Greenland ice-sheet (Mayewski et al, 1997, 2004). Similar spectral peaks are also seen in <sup>14</sup>C and <sup>10</sup>Be isotopes in Greenland GRIP ice-cores (Xapsos, 2009); these cycles have been attributed to solar sunspot activity (Solanki et al, 2004). Complicating the question of existence of global millennial cycles, a comparison of δ<sup>18</sup>O data in ice cores for Greenland (NGRIP) and Antarctica (EDML) has shown that for events prior to the Last Glacial Maximum (LGM), variations on the scale of 2-6kyr are markedly stronger in northern hemisphere records, associated with ice dynamics and Dansgaard-Oeschger (D-O) and Heinrich events (EPICA, 2006).

This paper discusses ocean sediment cores from three temperate zone and sub-tropical sites which provide sea-surface temperature (SST) histories using the UK37 proxy. The available time spans are 20, 70 and 136 ka. This study restricts the three records to 0-20ka thus avoiding complexities of D-O and Heinrich events, and of the associated phase changes between hemispheres which have been discussed by EPICA (2006). We apply Lomb-Scargle spectral analysis and find that all three sediment SST records (Okinawa Trough, Murray Canyon south of South Australia, and Iberian Margin) show a high-confidence 6000 yr period spectral peak for the time span 0-20ka; we may conclude that this post-LGM peak is unlikely to be related to glacial-epoch ice dynamics. The same 6000 yr spectral peak also shows in 0-20ka EDML δ<sup>18</sup>O data from EPICA (2006).

The three SST records also show spectral peaks in the range 1000 to 3500 yr periods. The high-resolution Okinawa Trough shows a clear 2300 yr (Hallstatt) peak and the Iberian Margin similarly. The peak is visible on southern hemisphere Murray Canyon data but is of doubtful significance. A unique feature of the Iberian Margin data is a strong 3400 yr spectral peak. This peak is also visible but much weaker on the other SST records, and on the 0-20ka EPICA δ<sup>18</sup>O data. We hypothesize the strong peak for the Iberian Margin is a consequence of effects of ocean and ice dynamics in the north Atlantic.

Similar spectral analysis of limited <sup>10</sup>Be data from McCracken et al 2013, (available length limited to 0-10ka) supports the hypothesis that millennial cycles in temperature (especially the 6000 yr and 2300 yr periods) are global and associated with cosmic ray/solar magnetic activity. This is in contrast with the longer Milankovich cycles which are well established as being primarily related

to forcing associated with variable solar insolation.