Relationship between 18.6-year period lunar tidal cycle and ENSO

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Bi-decadal variability is known to be a major component in the inter-decadal ocean and climate variability over the Pacific. Variations in vertical mixing induced by 18.6-year period nodal tidal cycle (18.6-yr cycle) are suggested as one of the causes of this bi-decadal variation. Previous studies showed that the north Pacific mid-high latitude SSTs and air temperature, surface and intermediate water masses in the subarctic North Pacific, the Aleutian Low Pressure, PDO (Pacific Decadal Oscillation) index etc. are synchronized with the 18.6-yr cycle (Yasuda et al., 2006; Osafune and Yasuda, 2006; 2010; Yasuda, 2009). Numerical climate model experiments with vertical mixing modulated with the period of 18.6 year near the Kuril Islands also suggested that the 18.6-yr cycle affects low-latitude Pacific and climate as PDO (Tanaka et al., 2012) and El Niño Southern Oscillation (ENSO) (Hasumi, et al. 2008). Although climate impacts from tropical variability as ENSO is large, there has been only one observational study that suggested relationship between intense El Niño and the 18.6-yr cycle; however the result (Cerveny and Shaffer, 2001) is not reliable because the analysis method used was inadequate. In the present study, long-term time series of ENSO indices (Southern Oscillation Index (SOI), NINO3-index, Cold Tongue Index (CTI) etc.) reconstructed from tree rings, etc. are analyzed to clarify the relationship between tropical climate and the 18.6-yr cycle. Furthermore, on the basis of ocean and atmosphere datasets, spatial structures of the 18.6-yr variability are examined to discuss mechanisms how the 18.6-yr cycle affects the tropical ocean and climate. Variations synchronized with the 18.6-yr cycle are detected by using “calendar composite analysis” in which the mean and its confidence interval are evaluated at each tidal year from the maximum diurnal tide in the 18.6-yr cycle. We here found 3.72 (=18.6/5)-year period variability based on a proxy record of December-February Southern Oscillation Index (SOI) reconstructed from tree-rings (Stahle et al., 1997), and showed that El-Nino (La-Nina) tends to occur in the 1st, 10th, 13th and 17th (3rd, 7th and 16th) year after the maximum diurnal tide in the 18.6-year cycle.
In the low-passed (5-year running mean) long-term time-series of ENSO indices during 1700s-1970s, statistically significant +SOI and -NINO3 is found to occur at the 4-5th tidal year from the maximum diurnal tide suggesting La Niña, and -SOI and +NINO3 at the 11-12th tidal year suggesting El Niño. These are consistent with the PDO-18.6yr cycle relationship (Yasuda, 2009). In the 10-30yr period band-passed SST/SLP during 1910-1997, low (high) SST in the tropical Pacific, high (low) SST in the mid-latitude central North Pacific, almost simultaneously weak (strong) Aleutian Low Pressure, high (low) SLP in the western tropics, and low (high) SLP in the eastern Pacific occurs at the 3-4th (12-13th) tidal year after the maximum diurnal tide in the 18.6-yr cycle.

Keywords: 18.6-year period lunar nodal cycle, ENSO, interdecadal ocean climate variability

