The multidecadal variability of El Niño-Southern Oscillation (ENSO)–South Asian monsoon relationship is elucidated in a 1000-year control simulation of a coupled general circulation model (GCM). The results indicate that the Atlantic Multidecadal Oscillation (AMO), resulting from the natural fluctuation of Atlantic Thermohaline Circulation (THC), plays an important role in modulating the multidecadal variation of ENSO–monsoon relationship. The sea surface temperature (SST) anomalies associated with the AMO induce not only significant climate impact in the Atlantic, but also the coupled feedbacks in the tropical Pacific regions. The remote responses in the Pacific Ocean to a positive phase of AMO resulted from enhanced THC in the model simulation are characterized by statistically significant warming in the North Pacific and in the western tropical Pacific, a relaxation of tropical easterly trades in the central and eastern tropical Pacific and a deeper thermocline in the eastern tropical Pacific. These changes in mean states lead to a reduction of ENSO variability, and therefore a weakening of the ENSO–monsoon relationship. This study suggests a non-local mechanism for the low-frequency fluctuation of ENSO–monsoon relationship. Given the fact that the multidecadal variation of THC and therefore of AMO exhibit decadal predictability, this study highlights the possibility that a part of the change of climate variability in the Pacific Ocean and its teleconnection may be predictable.