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Footprints of IOD and ENSO in the 115year-Kenyan coral record

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The Pacific El Nino/Southern Oscillation (ENSO) and the Asian monsoon have been considered the major influences on the climate variability in the Indian Ocean [Charles et al., 1997; Torrence and Webster et al., 1999]. The East African Rainfall variability also has been explained by the effect of the ENSO teleconnection. However, the correlation between the ENSO and Indian Ocean climate variability is not particularly strong and is suggested to have become weak in recent decades [Kumar et al., 1999]. In 1999 the Indian Ocean Dipole (IOD) was identified as another dominant climate mode generating climate variability not only in the Indian Ocean but also in the world along with ENSO [Saji et al., 1999]. The IOD is a seasonally fixed phenomenon that peaks between September and November. Positive IOD is normally characterized by anomalous cooling (warming) of SST in the eastern (western) Indian Ocean together with severe droughts over the Indonesian region and heavy rainfall over East Africa. But their past variations are obscure due to a lack of reliable instrumental observations before 1958 [Saji et al., 1999], which has prevented the evaluation of IOD inter-annual shift and its corresponding relation to ENSO and monsoon.

We found Kenyan coral oxygen isotope ratio (delta Oxygen) reflected distinctly the East African Short Rain anomaly related to the IOD variability in January, a few months after the Short Rain peak due to oceanographic condition, and reconstructed the 115-year Short Rain anomaly as the coral IOD index. The coral IOD index demonstrates a dominantly decadal periodicity in the early part of 20th century. This low-frequency IOD occurred more frequently before 1924 with more quasi-biennial events since 1960. The mode shift has also coincided with an intensified coupling with Indian summer monsoon rainfall. We suggest that a warming of the western Indian Ocean, which has attenuated and replaced the El Nino Southern Oscillation effect over the Indian Ocean, has driven the observed shift.

On the other hand, a comparison of the monthly coral delta oxygen pattern corresponding to IOD and ENSO years shows that the ENSO-induced signals do not appear clearly as the positive sea surface temperature (SST) and rainfall anomalies in the Kenyan coral record. This result supports the suggestion that the IOD is the dominant climate mode rather than ENSO in the Kenyan coast. Moreover the coral records indicate that the negative IOD like- anomalously cold SST condition in the western Indian Ocean precedes the evolution of the Pacific El Nino by one year. The anomalously cold SST condition was prominent in the late 19th century, but weakened in the 20th century. This retreat of the cold SST condition due to warming of the western tropical Indian Ocean may influence the nature of the Pacific ENSO.

Keywords: IOD, ENSO, East African Rainfall, Kenya, coral record