Figure 4. Relative change of time-averaged Hilbert frequency (in units of oscillations/year). (a) Average in the first ten years (1979–1988). (b) Average in the last ten years (2007–2016). (c) Relative change of Hilbert frequency, $\Delta\omega/\langle\omega\rangle$. (d) Relative change of the number of zero-crossings of the normalised SAT time series. In (a) and (b) the colour scale is adjusted to represent in white the regions where the average frequency is one oscillation per year. In (c) and (d), a good qualitative agreement of spatial structures is seen; however, we note that Hilbert frequency detects stronger variations than those measured by the number of zero-crossings.

areas where the frequency increases (decreases) correspond to areas where the number of zero-crossings increases (decreases). We note that the relative variations in Hilbert frequency are more pronounced than those in the number of crossings, and this specifically holds in the regions where frequency variations are interpreted in terms of ITCZ migration.

Figures 5(a) and 5(b) display SAT time series in the dipole region indicated with the circle in Fig. 4(c), and also indicate (in red) the zero-crossings. We can understand the difference that was detected in this region between the variance of Hilbert amplitude (Fig. 3a) and the variance of anomaly (Fig. 3b). This difference is explained in the following terms: in the first decade the seasonal cycle is more irregular than in the last decade, probably a consequence of an El Niño event in 1982–1983. The anomaly series contains these slow fluctuations as well as the rapid ones, and thus its variance is affected by both effects. In contrast, the Hilbert amplitude is less affected by the slow fluctuations as its variance captures mainly the rapid fluctuations of SAT.