In this study, the authors investigate the observed record-breaking SST events by comparing with the expected rate for a trend-free random variable (TFRV). The authors find the asymmetric nature of the high and low records and reveal islands of cooling in the North Atlantic and Southern Ocean. The record-breaking theory is interesting; however, the assumption of the theory may not be enough reliable and the results may be sensitive to the length of a time series. Given these issues, I would recommend that this paper is not suitable for publication in this high-rank journal. More specific comments are listed as below.

Major comments:

1. The results of this study depend mainly on the comparison with the TFRV model. However, the climate system is clearly not a TFRV. Significant trends in SST can be detected even without the influence of human-induced greenhouse gases. As Deser et al.(2013) and Wallace et al. (2015), the internal variability is important for multi-decadal trends in climate variables, which are independent of human activities.

The authors use only a trend-free model for comparison, which is more of a hypothesis testing tool to test observed trends. and is of little implication for the climate community to understand the observations and climate change.

It is suggested that considering internal trends of the climate variables, such as add the trend distribution of Pre-industrial experiments from CMIP5/6 into the record-breaking statistics and comparing it with observed data, may yield more valuable results.

2. The results may depend to a large extent on the sample size. As shown in Equation 2, the broken k-record varies with the length of the time series. In other words, the results may be sensitive to the length of the time series and not robust.