Time-series analysis of sea surface temperature and El Niño-Southern Oscillation (ENSO) dynamics

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Nowadays it is known that El Niño is one of the three phases of the El Niño Southern Oscillation (ENSO) phenomenon caused by the interannual sea surface temperature variations of the tropical Pacific. The ENSO alternate between the stages: El Niño state - when the sea surface temperature of the Equatorial Pacific Ocean increases significantly, La Nina state that is the opposite behavior, and the neutral state. Although this process happens in a particular place, its consequences like winds, droughts, and floods are noticed throughout the globe. The sea surface temperature changes are caused by the surface wind fluctuations shown a strong interaction between ocean and atmosphere. In this work, we have tried to understand the predictability of the ENSO using a specific variable: the sea surface temperature (SST). All data used were taken from National Oceanic and Atmospheric Administration (NOAA), and the gaps and small failures on that time series were handled by Holt-Winters forecasting method. To understand the behavior of these time-series, we have made the reconstruction of the phase space by the Takens’s time-delay method and using the Grassberger-Procaccia algorithm we calculate the dimension of correlation for some embedding dimensions of the system. Our sample dataset capture locally, with good correlation, the regional Oceanic Niño Index (ONI) and show the behavior anomalous pictured by ONI, a measure of ENSO known to detect El Niño / La Niña. Our results show the existence of attractors in the dynamic described by these time-series embedded on high dimensions. The Largest Lyapunov Exponent and the Kolmogorov-Sinai entropy shown evidence on the sensitivity to initial conditions and the possibility of transitions to chaos.

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