Nonlinear Processes in Geophysics

Supporting Information for

Inverse Differential Equation Modeling of ENSO Prediction Based on Memory Kernel Functions

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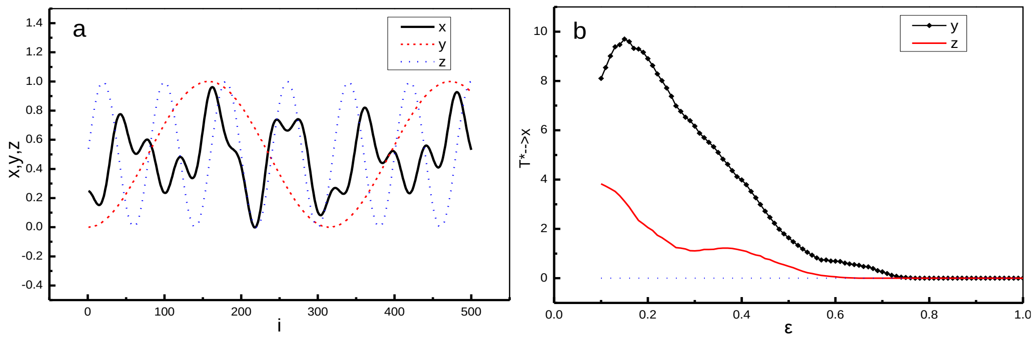

Figure S1: (a) evolution diagram of *X*, *Y*, and *Z*; (b) information transfer from *Y* and *Z* to *X* ($T_{*\to X}$ represents the amount of information about *X*)

Transfer entropy is a three-variables analysis method proposed in 2005. Its mathematical essence is to assess the relationships between three variables by conditional probability. Entropy, as a function of state, originally originated from thermodynamics and statistical mechanics, and its essence is to describe the disordered state within a material system. For a closed system, entropy typically increases, indicating the system always tends to reach its maximum state of disorder. The physical significance of transfer entropy represents the energy exchange between systems, and attempts to obtain maximum information exchange through various pathways to achieve equilibrium. According to the definition, information exchange is most intense in the small scale, resulting in greater randomness (disordered state). As the influence scale increases (i.e., with an increase in ε), this disorder decreases, and the information exchange gradually weakens. The following used an ideal dynamic system as an example to describe the physical meaning in Equation (1).

$$x_i = y_i[18{y_i}^2 - 27y_i + 10]/2 + z_i(1 - z_i) + ln(y_i z_i + 1)$$
$$y_i = [1 - cos(2\pi i/315)]/2 \tag{1}$$
$$z_i = [1 + sin(2\pi i/80)]/2$$

Its evolution characteristics are shown in Figure S1.