Supplement: Nonlinear causal dependencies as a signature of the complexity of the climate dynamics

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1 Additional figures

This supplement contains the additional figures of the manuscript. It displays the rate of information transfer of a set of climate indices on one another. Two types of analyses are made: first based on assuming linear influences between them, and second assuming that there are also nonlinear quadratic influences. The figures for the Arctic Oscillation, AO (Figs. S1 and S2), the Pacific North American pattern, PNA (Figs. S3 and S4), the Atlantic Multidecadal Oscillation, AMO (Figs. 5 and 6), the Pacific Decadal Oscillation, PDO (Figs. S7 and S8), the Tropical North Atlantic index, TNA (Figs. S9 and S10) and the Quasi-Biennal Oscillation, QBO (Figs. S11 and S12), are displayed here. The figures for the El Niño3.4 index and the North Atlantic Oscillation, NAO, are shown in the main document and discussed in details. The analysis of the figures in the current document is also provided in the main document.

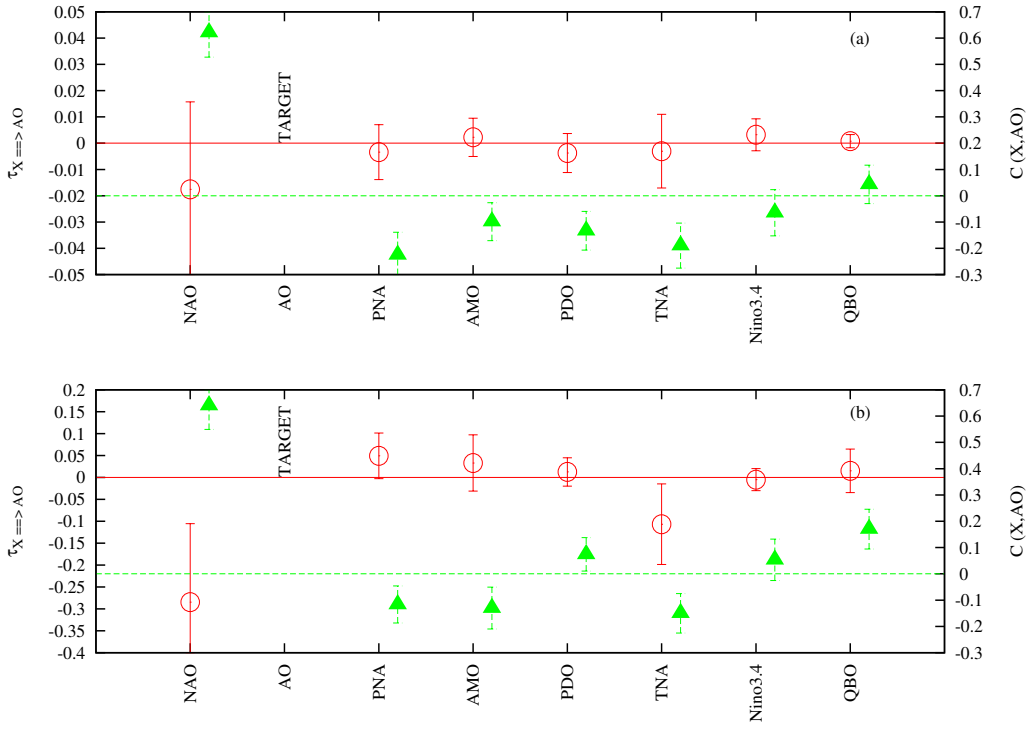

Figure S1. The rate of information transfer (left y-axis, red open circles) and the correlation (right y-axis, green full triangles) are plotted as a function of the observables for the targeted observable (labelled TARGET in the plot): the AO. Panels (a) and (b) are for the original and Low-Frequency (LFV) time series, respectively.

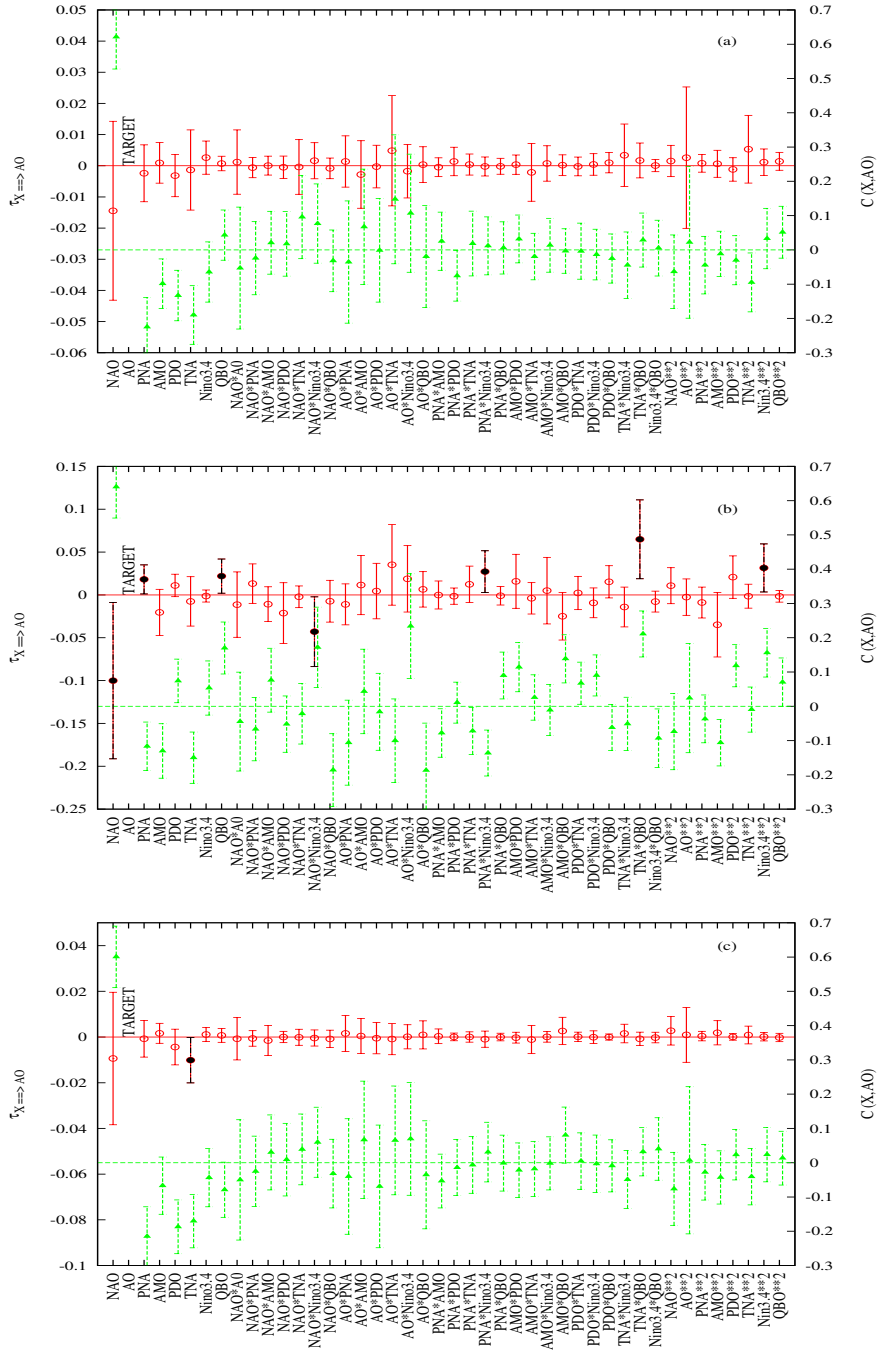

Figure S2. The rate of information transfer (left y-axis, red open circles) and the correlation (right y-axis, green full triangles) are plotted as a function of the observables for the targeted observable (labelled TARGET in the plot): the AO. Panels (a), (b) and (c) are for the original, the LFV and the high-frequency time series, respectively. The observable set is composed of 7 linear terms and 36 nonlinear quadratic terms, all listed along the x-axis. The points in black refer to the significant dependencies at the 1% level.

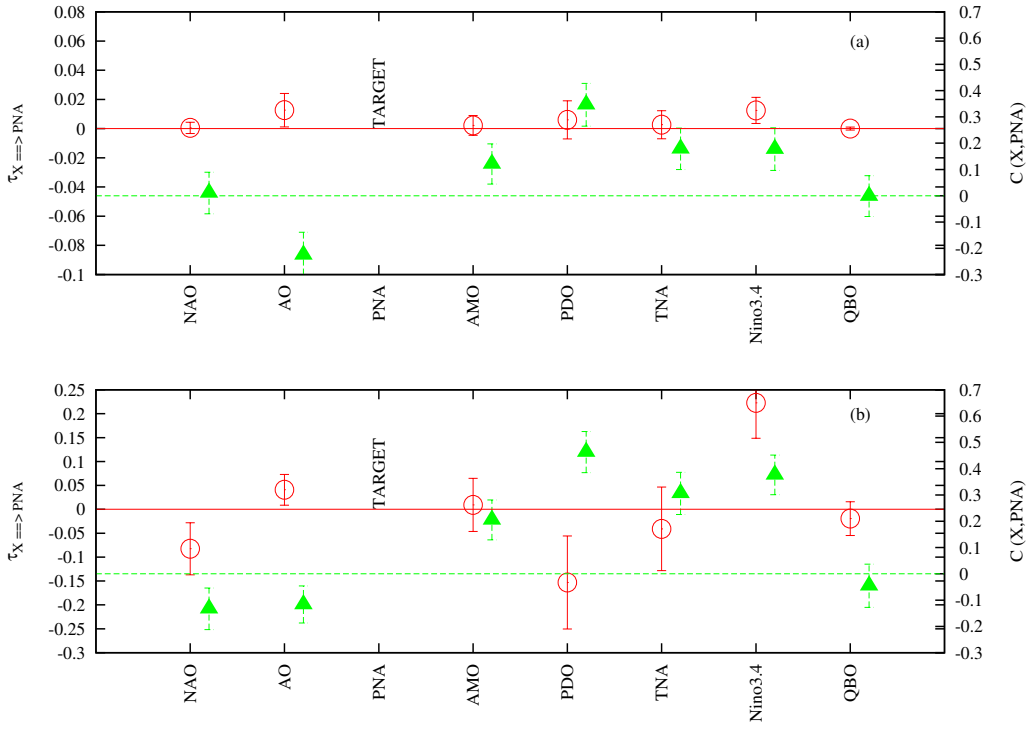

Figure S3. The rate of information transfer (left y-axis, red open circles) and the correlation (right y-axis, green full triangles) are plotted as a function of the observables for the targeted observable (labelled TARGET in the plot): the PNA. Panels (a) and (b) are for the original and LFV time series, respectively.

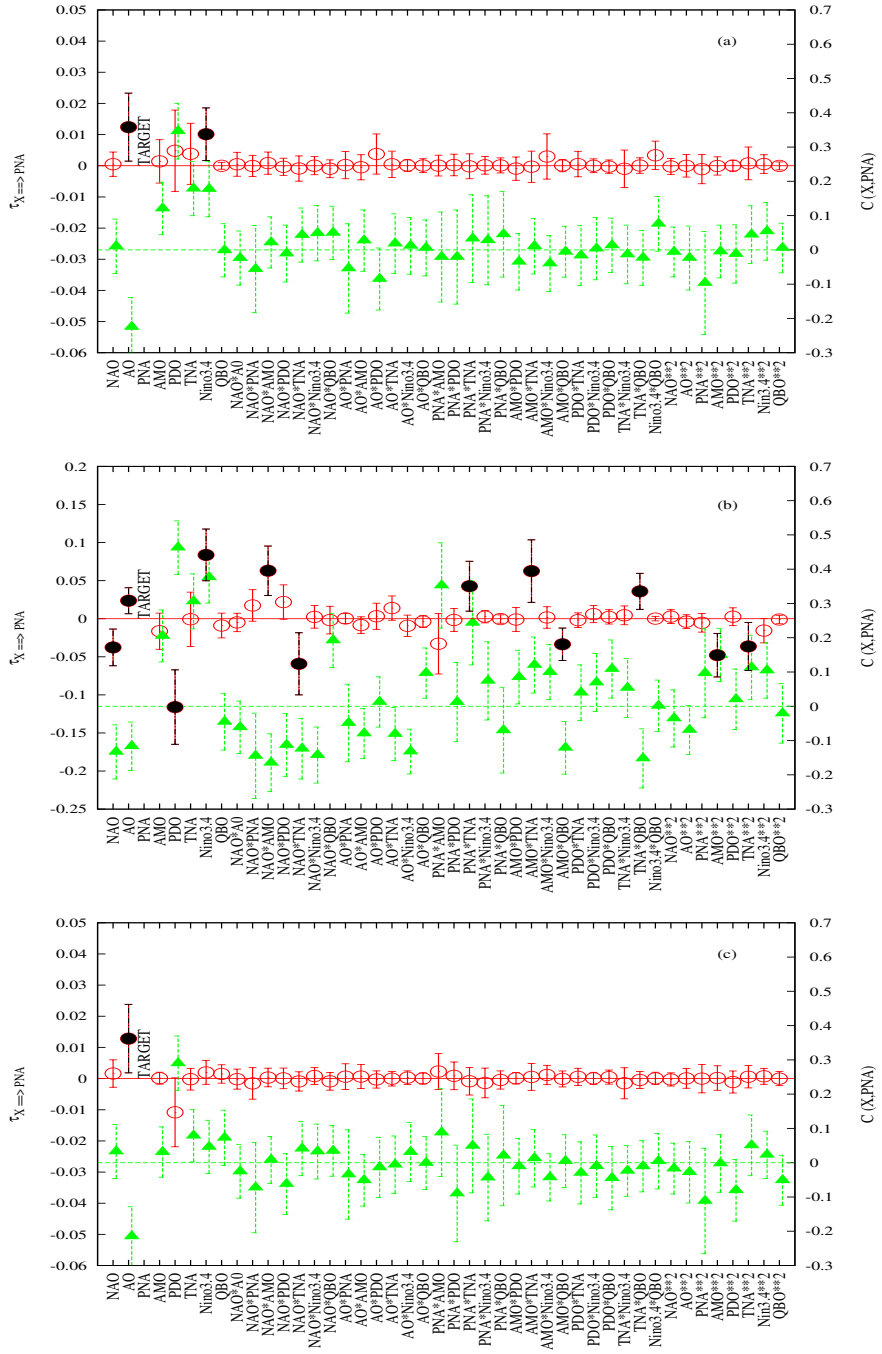

Figure S4. The rate of information transfer (left y-axis, red open circles) and the correlation (right y-axis, green full triangles) are plotted as a function of the observables for the targeted observable (labelled TARGET in the plot): the NAO. Panels (a), (b) and (c) are for the original, the LFV and the high-frequency time series, respectively. The observable set is composed of 7 linear terms and 36 nonlinear quadratic terms, all listed along the x-axis. The points in black refer to the significant dependencies at the 1% level.

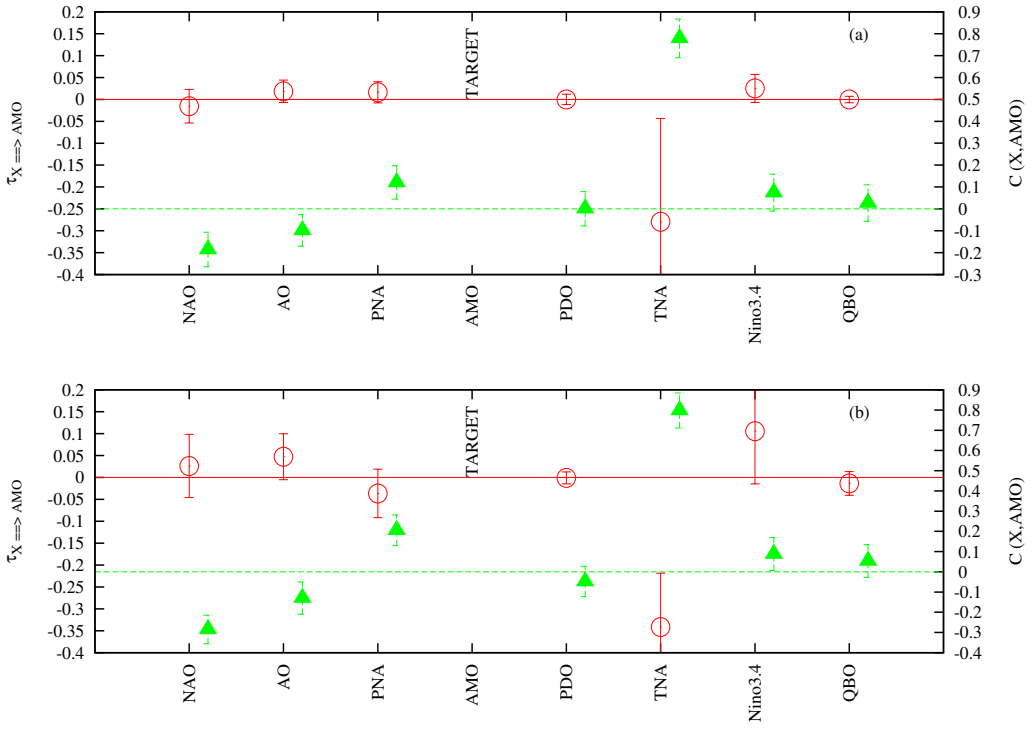

Figure S5. The rate of information transfer (left y-axis, red open circles) and the correlation (right y-axis, green full triangles) are plotted as a function of the observables for the targeted observable (labelled TARGET in the plot): the AMO. Panels (a) and (b) are for the original and LFV time series, respectively.

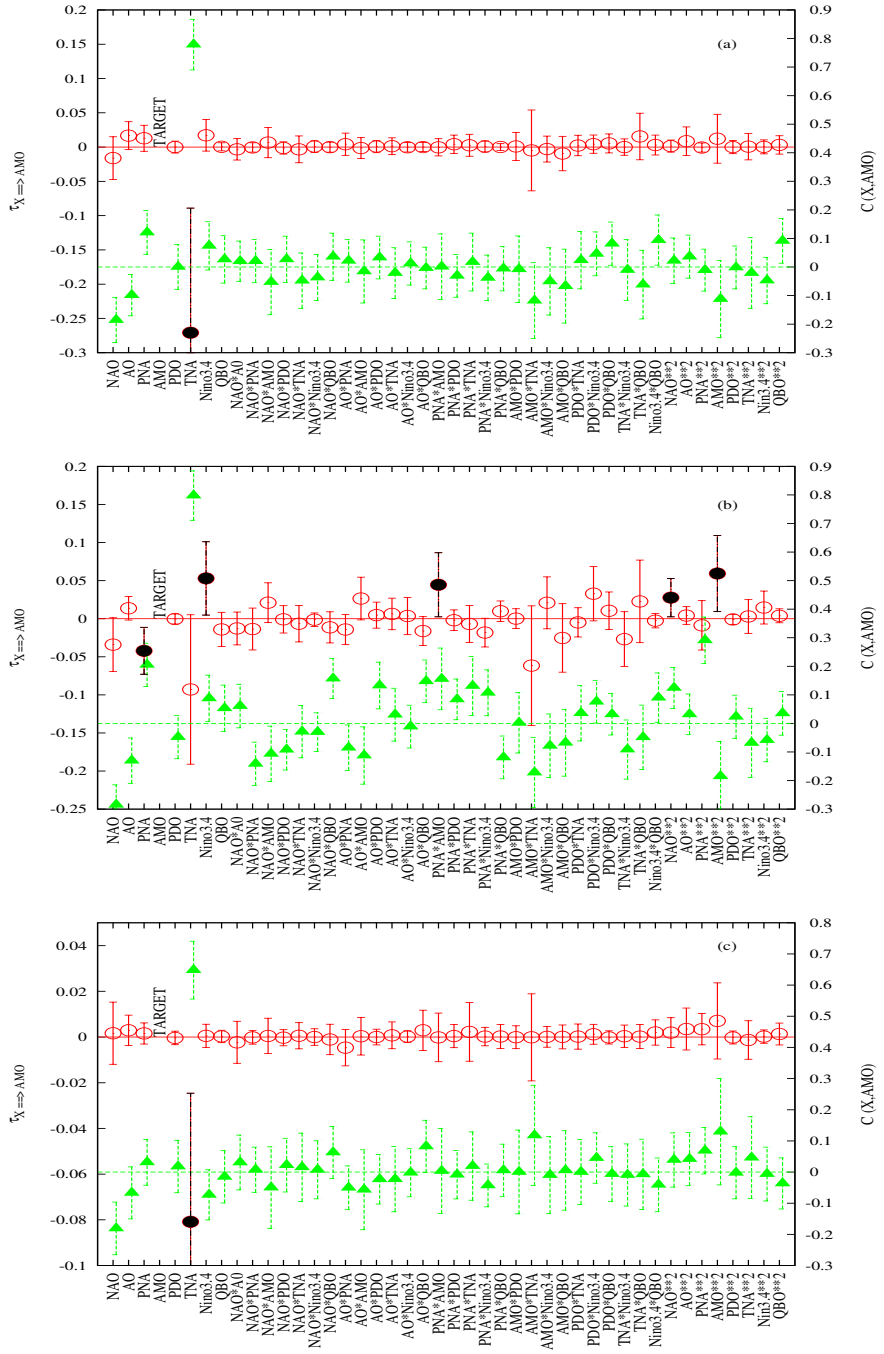

Figure S6. The rate of information transfer (left y-axis, red open circles) and the correlation (right y-axis, green full triangles) are plotted as a function of the observables for the targeted observable (labelled TARGET in the plot): the AMO. Panels (a), (b) and (c) are for the original, the LFV and the high-frequency time series, respectively. The observable set is composed of 7 linear terms and 36 nonlinear quadratic terms, all listed along the x-axis. The points in black refer to the significant dependencies at the 1% level.

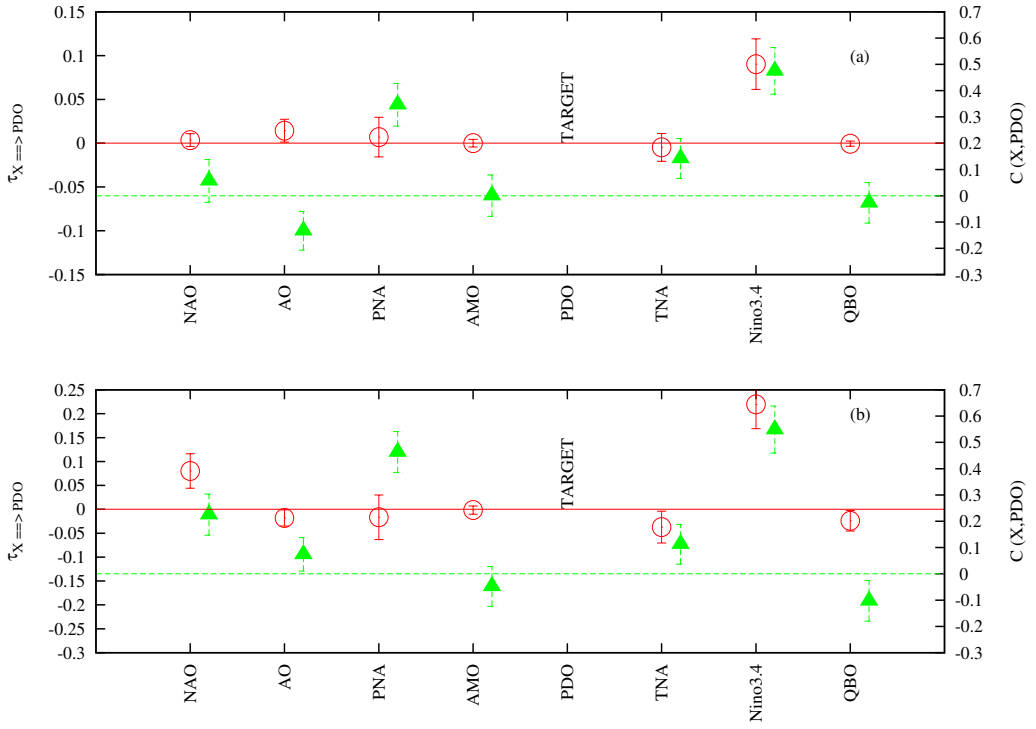

Figure S7. The rate of information transfer (left y-axis, red open circles) and the correlation (right y-axis, green full triangles) are plotted as a function of the observables for the targeted observable (labelled TARGET in the plot): the PDO. Panels (a) and (b) are for the original and LFV time series, respectively.

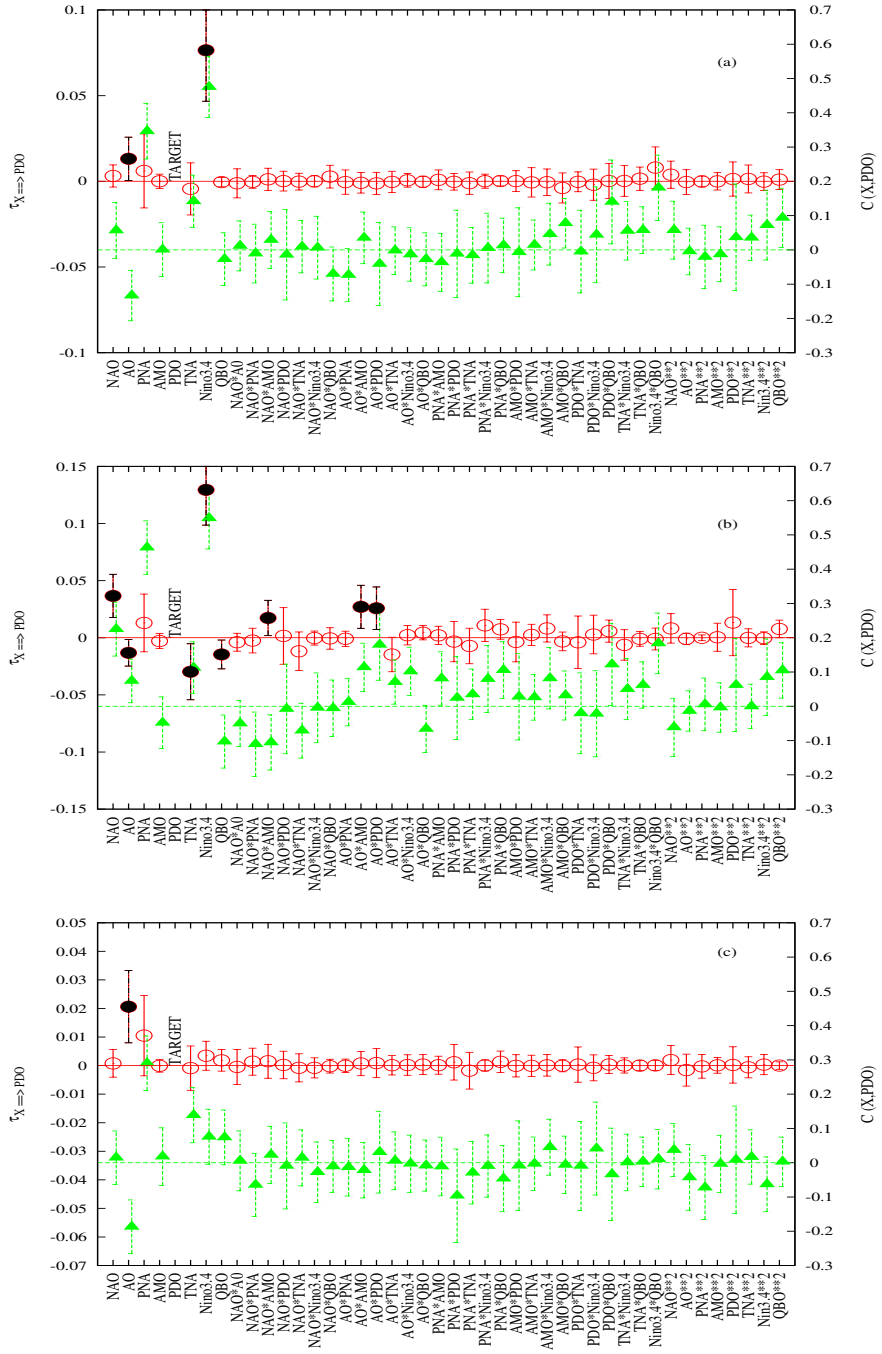

Figure S8. The rate of information transfer (left y-axis, red open circles) and the correlation (right y-axis, green full triangles) are plotted as a function of the observables for the targeted observable (labelled TARGET in the plot): the PDO. Panels (a), (b) and (c) are for the original, the LFV and the high-frequency time series, respectively. The observable set is composed of 7 linear terms and 36 nonlinear quadratic terms, all listed along the x-axis. The points in black refer to the significant dependencies at the 1% level.

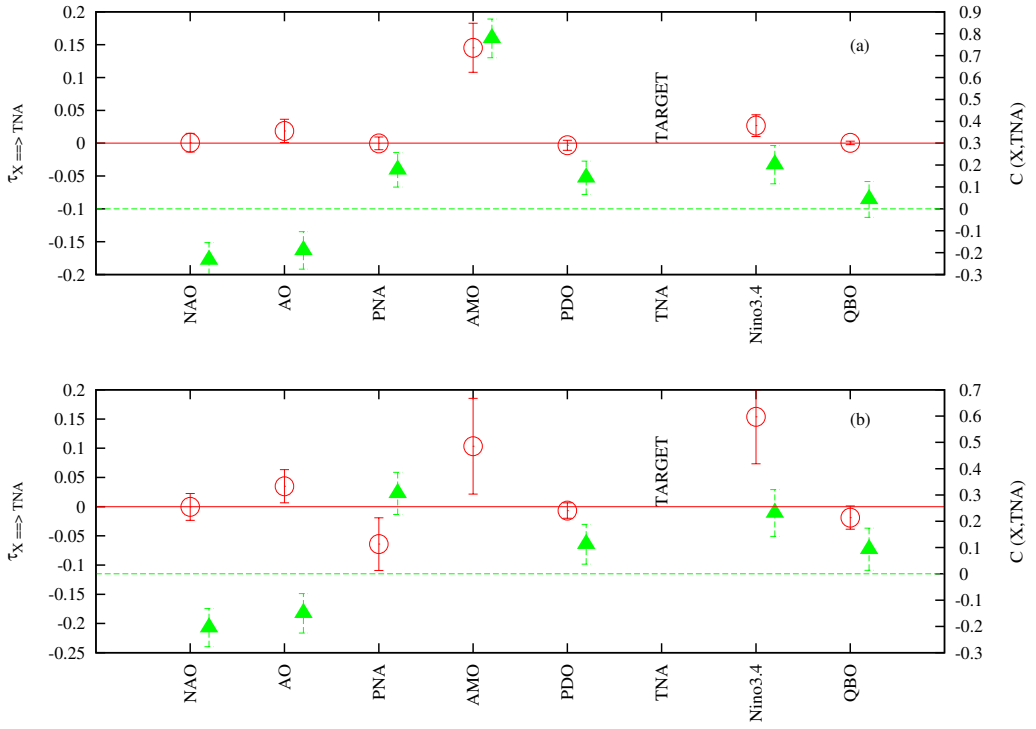

Figure S9. The rate of information transfer (left y-axis, red open circles) and the correlation (right y-axis, green full triangles) are plotted as a function of the observables for the targeted observable (labelled TARGET in the plot): the TNA. Panels (a) and (b) are for the original and LFV time series, respectively.

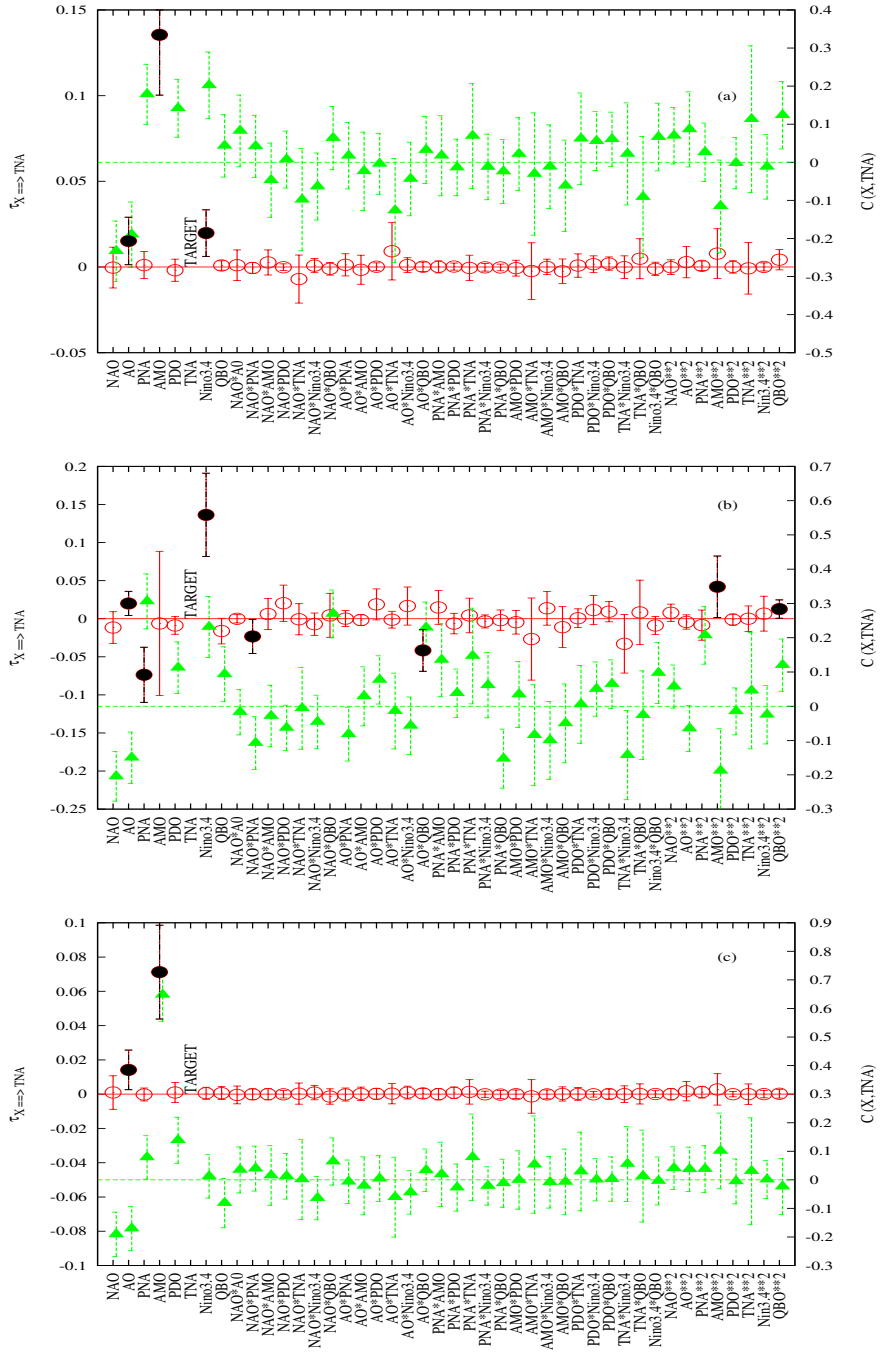

Figure S10. The rate of information transfer (left y-axis, red open circles) and the correlation (right y-axis, green full triangles) are plotted as a function of the observables for the targeted observable (labelled TARGET in the plot): the TNA. Panels (a), (b) and (c) are for the original, the LFV and the high-frequency time series, respectively. The observable set is composed of 7 linear terms and 36 nonlinear quadratic terms, all listed along the x-axis. The points in black refer to the significant dependencies at the 1% level.

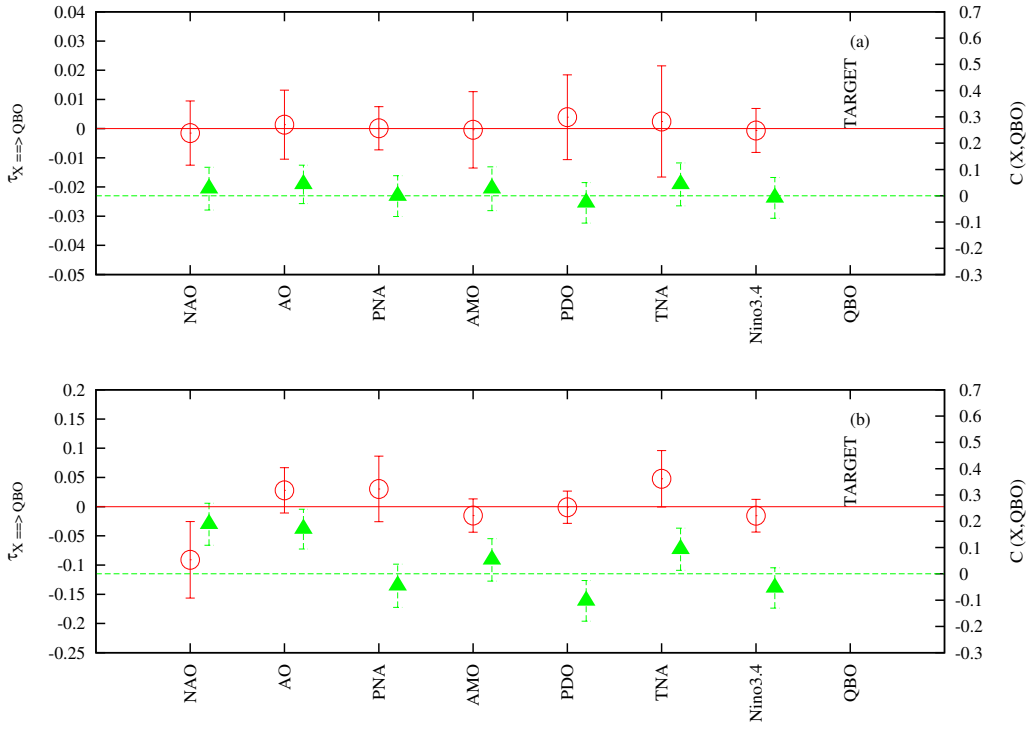

Figure S11. The rate of information transfer (left y-axis, red open circles) and the correlation (right y-axis, green full triangles) are plotted as a function of the observables for the targeted observable (labelled TARGET in the plot): the QBO. Panels (a) and (b) are for the original and LFV time series, respectively.

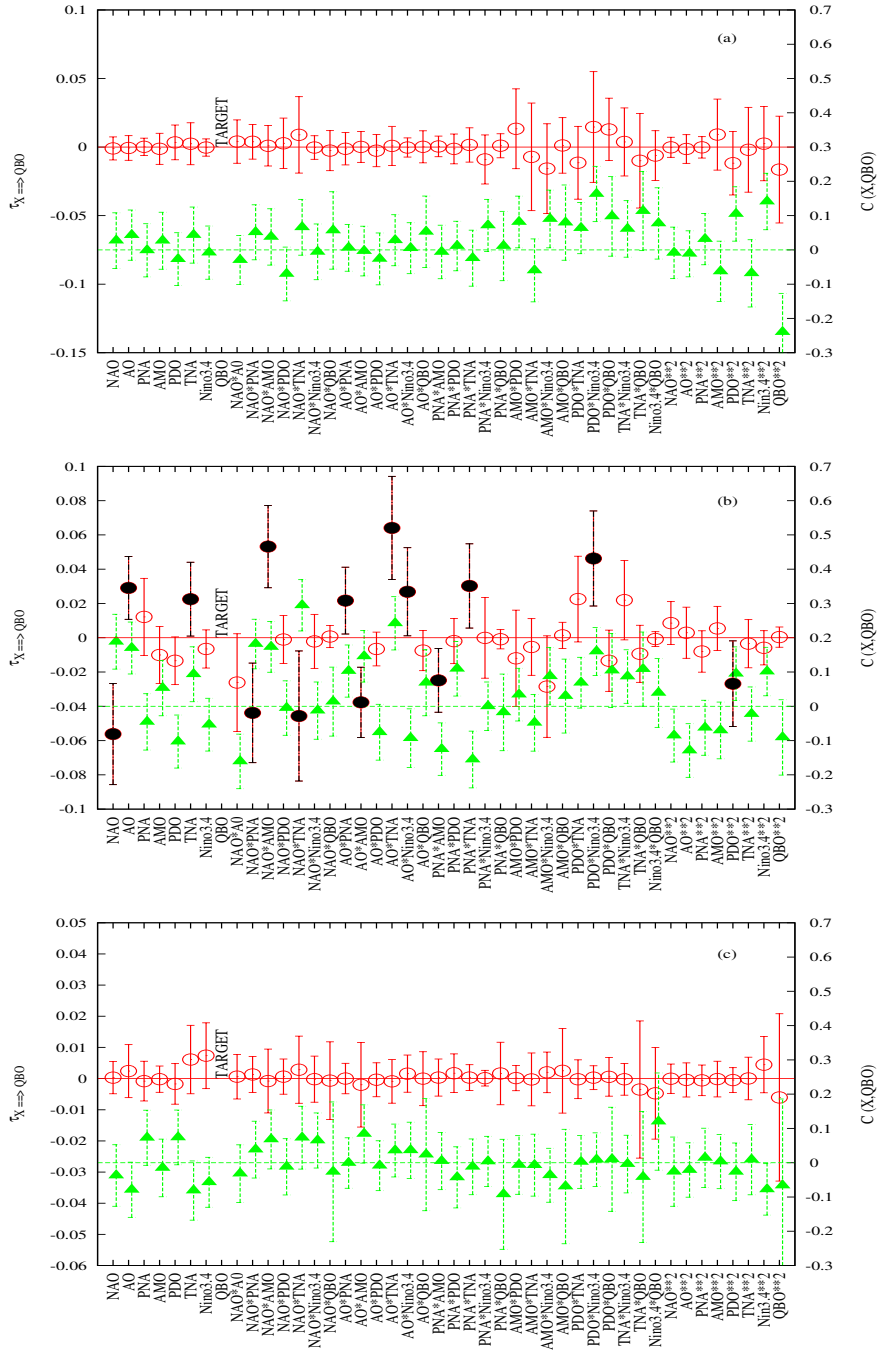

Figure S12. The rate of information transfer (left y-axis, red open circles) and the correlation (right y-axis, green full triangles) are plotted as a function of the observables for the targeted observable (labelled TARGET in the plot): the QBO. Panels (a), (b) and (c) are for the original, the LFV and the high-frequency time series, respectively. The observable set is composed of 7 linear terms and 36 nonlinear quadratic terms, all listed along the x-axis. The points in black refer to the significant dependencies at the 1% level.