# Triadic Non-Gaussian teleconnections in the Sea Surface Temperature Field: a source of interannual predictability coming from triadic wave resonances

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Analysis of centennial (1910-2012) time-series of the monthly Sea Surface Temperature anomalies (SSTAs) around the global ocean (extracted from the NOAA ERSST v3b dataset) shows clear evidence of non-Gaussian multivariate PDFs on certain projections, as an indication of both nonlinear correlations and nonlinear teleconnections. Beyond that, we still get statistical non-Gaussian relationships involving sets of three pair-wise uncorrelated variables through the occurrence of statistically significant and cross-validated triadic correlations (TCs),reaching $\sim$30% in certain cases, i.e. non-null third-order cross cumulants between three standardized principal components (PCs) of the SSTA field, which would vanish under multivariate Gaussianity. Further enhanced TCs are obtained in the space of orthogonally rotated standardized PCs by expressing them as a function of the generalized Euler rotation angles and then maximized by gradient-descent methods. There are multiple triads depending of the embedding space of PCs where triads are sought. Furthermore they have no preferred order due to non-unique solutions of the non-linear matricial equations to be solved in the optimization.

Triadic correlation is a particular form of the triadic interaction information, defined as the parcel of the mutual information (an Information-Theoretic measure of statistical dependency) which is atributed to triadic statistical synergies, not explained by pair-wise relationships.

Spatial patterns of the triad's components generally exhibit wave-like structures in spatial quadrature and satisfying the triadic wave resonance condition. Examples of triads are given in spaces spanned by the leading EOFs of the SSTA field and projecting mostly in the Pacific Ocean (e.g. El Niño, Pacific Decadal Oscillation, North-Pacific Gyre Oscillation and pattrens of waves crossing the Pacific basin). A triadic correlation means a non-null Pearson correlation between the product of any two variables and the remaining third one. This nonlinear correlation may exhibit memory extending to months or years and may even be responsible for some skill recovery at the decadal scale. The triadic cumulant may de decomposed into Fourier cross bi-spectrum terms relying on components satisfying the triadic wave resonance. This holds when the frequency (in cycles per century) of a Fourier component is the sum of frequencies of the other two Fourier components. Therefore, dominant resonances between components interacting constructively, i.e. satisfying the appropriate phase relationship, can be considered as nonlinear sources of predictability on scales ranging from months to decades. The triads and indices derived from them can be used in schemes of long-range forecasting and downscaling.