Geophysical Research Abstracts
Vol. 16, EGU2014-14203, 2014
EGU General Assembly 2014

Triadic Non-Gaussian low-frequency Teleconnections in the Atmosphere and Ocean

Carlos Pires (1) and Rui Perdigão (2)

(1) Universidade de Lisboa, Instituto Dom Luiz (IDL) - Faculdade de Ciencias, Edifício C8, Lisboa, Portugal (clpires@fc.ul.pt), (2) Institute of Hydraulic and Water Resources Engineering, Vienna University of Technology, Vienna, Austria (perdigao@hydro.tuwien.ac.at)

Teleconnections (TCs) normally rely upon long distance and simultaneous/lagged non-zero correlations of a geophysical field. However, for non-Gaussian multivariate probability distributions like that of the space spanned by low-frequency atmospheric-oceanic components, the linear Pearson correlation can be zero whereas some nonlinear correlation is nonzero. Therefore, in the non-Gaussian world, TCs can only be correctly assessed by the multiinformation (MI) - generalization of mutual information for any number of variables.

Non-Gaussianity of spatially-distributed geophysical complex networks, still allows for a more 'exotic' behavior (triads), where three variables X,Y,Z (e.g. field values taken at three mutually distant points) are uncorrelated or even pair-wised statistically independent, (i.e. vanishing mutual information I(X,Y)=I(X,Z)=I(Y,Z)=0), while the triadic MI I(X,Y,Z) is greater than zero. These 'threesome' TCs (perfect and almost perfect triads) are shown to exist in the atmospheric-oceanic monthly-decadal timescale variability. In order to show that, two datasets are used: a) monthly-running averages of the stream-function fields issued from a million-day run of a quasi-geostrophic 3-level, T21 model (QG-model); b) annual-running SST averages for the 1880-2012 period, taken from GISS. The intensity of triadic TCs are measured by the interaction multiinformation (IMI) II(X,Y,Z)=I(X,Y,Z)-[I(X,Y)+I(X,Z)+I(Y,Z)] which is positive (negative) in case of synergy (redundancy) among variables. A relevant remark is the fact that the coarse-grained IMI version is maximal when the categorical variable outcomes satisfy a Latin-Square relationship (e.g. the Boolean exclusive disjunction of 2 symbols, i.e. Z=Xand/orY, the Sudoku game of 9 symbols).

We devise an optimization gradient-descent-based algorithm for finding triads in the space of orthogonally rotated normalized principal components (RN-PCs) of the analyzed field. RN-PCs (X,Y,Z) are uncorrelated by construction, and thus the pair-wised MIs are close to zero as whished. Moreover, rotations are restricted to the few (Nrot) leading variance-explaining PCs assuring that the sub-space spanned by triads do not project onto noisy components. In order to accomplish that, we find local maxima (and then the absolute maximum) of a proxy-functional F(X,Y,Z) of II(X,Y,Z), for instance the monomial expectation E(XYZ), which is proportional to the correlation between a product of two arbitrary chosen variables with the third one. The control vector is filled up by the Nrot(Nrot-1)/2 Euler angles spanning all the possible orthogonal rotations on a Nrot-dimensional metric space. That proxy-functional relies upon the set of previously estimated third order moments among the unrotated N-PCs. Positive E(XYZ) means that, either the three time-series of X,Y,Z are positively-phased or, two out of the three variables are negatively-phased with the third one positively-phased.

As regards the dominant triads, maximizing F(X,Y,Z) for a given Nrot dimension, we compute temporal correlation maps between either X,Y or Z and the original field. The corresponding spatial patterns project mainly on Rossby waves (maybe in triadic resonance) for the case of the QG-model. For the case of interannual SST variability, we find patterns, somehow projected onto the El-Niño, AMO, PDO and other patters. The main triadic interacting SST patterns seem to be: 1) The zone of Atlantic and Pacific cold currents; 2) The California current zone; 3) The Equatorial Counter-current zone.

The teleconnecting triads may be useful for characterizing the nonlinear non-Gaussian variability as well as for studies of long-range predictability.

Work supported by the Portuguese Science Foundation (FCT) under the project PTDC/GEO-MET/3476/2012.