Author's Response to Referees of the manuscript: 'Non-Gaussian interaction information: estimation, optimization and diagnostic application of triadic wave resonance' by Carlos A. L. Pires and Rui A. P. Perdigão

Reply to RC C569

Thank you very much for your relevant questions and your contribution for the improvement of the manuscript.

Referee question 1) It is not so clear to me what we have now learned by applying this new framework to the Lorenz-95 model. Okay, there are nonlinear correlations but does their knowledge potentially improve predictability? Do we learn something new about the dynamics? I encourage the authors to discuss this in section 5.

Author's response: The reviewer aptly wonders what we have learnt about the Lorenz-95 dynamics. Actually, nothing substantially new in that particular regard. The use of Lorenz-95 (instead of a more complex fluid dynamics model) is essentially to illustrate the usefulness in a minimal advective model of the triadic correlation and its optimization as a statistically-based method for extracting spells of triadic wave resonance (TWR) behavior from a fully chaotic regime and the modes where that behavior is more intense in average. The advantage of the presented method, besides its generality, is the fact of being presented outside the context of the linear and quasi-linear theory of fluid waves where normally TWR is treated. In this minimal model, triadic correlation is linked to TWR as shown theoretically with a clear relationship between Fourier wave-numbers. However in more complex models, triads can be rather more subtle and complex. In this respect, preliminary results of the same method, applied to a million-day-size run from a quasi-geostrophic, baroclinic, T21 model, with surface NH winter forcing (Marshall and Molteni, 1996 model), have also shown the presence of relevant triadic correlations up to 0.45. The TWR is more subtle there because of the heterogeneous planetary forcing. Moreover, the spatial signature of triad loads is controlled by that heterogeneous forcing.

The question of the predictability that triads could add when included in an empirical, dynamical or in a qualitative model for forecasting purposes, is a quite important and interesting matter that should be thoroughly addressed in an independent study. We hereby express some of our ideas about the subject.

The attractor presents some slight distortion with respect to the multivariate Gaussian ellipsoid with the leading EOFs as axes and where the bulk of probability lies. The non-Gaussian triadic correlation is a statistical explanatory variable measuring that distortion in some sense. Therefore an improved statistical attractor's structure description is welcome.

Leading PCs can be used as climatic, meteorological or oceanic indices (e.g. El Niño), taken as predictors or dynamical variables in simple forecasting and downscaling models. Indices can be improved, by taking into account triadic correlations since they are better describing the

attractor's statistics, by considering non-linear indices like $Y_1+cY_2Y_3$ or $Y_1Y_2Y_3$ where Y_1,Y_2 ,Y_3 are the variables involved in a relevant triad.

Besides the above aspect, resonance is a source of predictability of a certain oscillatory behavior which can be driven either by an external forcing with an appropriate resonance frequency or through the interaction of internal field waves. Therefore, the triadic product $Y_1Y_2Y_3$ can possibly be used as an instantaneous indication of that resonance. Regarding this aspect, it is worth to explore the triadic lag-correlation: e.g cor[$Y_1(t+\Delta)$, $Y_2(t)Y_3(t)$] and use that for prediction thus improving predictability.

Author's changes in manuscript: We include the above comments in the Discussion (section 5) in a new paragraph.

Referee question 2) Page 1550, line 16: I don't understand the meaning of 'amount of constraint'. That sentence should be rewritten to make it understandable.

Author's response: Thank for your comment. You are right and the sentence will be rewritten. The old sentence is:

The components of Y_{proj} interact in a certain sense (e.g. physically), therefore they are statistically constrained with the amount of constraint being measured by information or the MII.

In fact, since statistical dependence is a synonym of closeness to certain determinist relationships mixing variables, the 'amount of constraint' shall be replaced by 'strength'.

Author's changes in manuscript: The new sentence is:

The components of $\boldsymbol{Y}_{proj}$ interact in a certain sense (e.g. physically), therefore they are statistically linked between each other, with the strength of their inter-relationships or the closeness to certain geometric or deterministic cross-constraints being measured by information or the MII.

Referee questions 3,4,5)

All the typos and the reference are now corrected.

Figure B2 caption: 'squares' is substituted by 'triangles'.

Reply to RC C644

Thank you very much for analyzing the manuscript and for your kind words, recognizing the overall work and the potential applicability of the new method to other domains.