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Nonlinear Processes in Geophysics
Discussions

Interactive comment on "Brief Communication: Breeding vectors in the phase space reconstructed from time series data" *by* E. Lynch et al.

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Referee Comment:

The authors of "Breeding vectors in the phase space reconstructed from time series data" presented an interesting approach to detect the behavior of breeding vectors using only a one-dimensional time series. The authors use the well known embedding technique to observe the growth rate and the spatial structure of perturbations starting from a fixed distance.

The paper is interesting but I have two main issues:

a) in a seminal work of Lyapunov exponents determination starting from one dimensional time series Brown, Bryant and Abarbanel, PRA 43, 2787 (1991) "Computing the Lyapunov spectrum of a dynamical system from an observed time series" the authors discuss in detail the importance to use two dimensions in computing the exponents. This is probably related to the choice of the integer l discussed at page 1306. Please discuss the relation between the choice of this paper and that given by Brown et al. namely the first minimum in the mutual information. I think that the authors should discuss the effect of changing l in their findings.

b) The example given on the standard Lorenz model is, in my opinion, not sufficient. The authors should test their technique on more complicated models like, for example, the Lorenz 96 model where the system dimension is larger than 3 and the embedding technique becomes more difficult to be applied. After the authors address the two points I raised the paper can be considered for publication.

Author Comment:

We thank the referee for taking the time to review our manuscript and provide us with these thoughtful comments. We appreciate the recommendation that our paper be considered for publication and address the issues raised below.

To address the first point, the exclusion of points along the control trajectory is simply to ensure that the growth of separation between the control and perturbed trajectories is due to the nonlinear dynamics of the system rather than displacements along the control trajectory, as Brown et al. discuss in the referenced paper. We based our estimation of the number of points to exclude on the estimate for the time delay for the x(t) data, which we obtained by the same method as Brown et al., i.e. the first minimum of the average mutual information function. This ensures that the neighboring points used as perturbed trajectories are nearby due to the structure of the attractor and not just correlated in time. As long as sufficiently many points are excluded that the nearest neighbor to the perturbation tends to lie along a different orbit from the control

trajectory, the numerical value of l does not have much effect on the results.

Brown et al (also the review: Abarbanel et al. RMP 1993) address the issue of spurious exponents due the inaccuracies or local features in the reconstructed space. The analysis in our paper is on the largest Lyapunov exponent and the existence or nature of spurious exponents would not affect the conclusions of the paper.

The main result of this paper is that the application of breeding to a reconstructed phase space without the use of a dynamical model is a viable data driven method. To achieve this in the brief communication we have presented our results on the Lorenz63 model. It is our hope that this paper will stimulate similar studies that explore the extension of this technique to other models and systems. We have applied similar techniques to those outlined here to real data and expect to present those in future publications. As a brief communication, it would not be possible to add additional results without altering the format of the article.

Interactive comment on Nonlin. Processes Geophys. Discuss., 2, 1301, 2015.