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Dimensionality Reduction for Multivariate Phase Space Reconstruction

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In nonlinear chaotic modelling, the reconstructed phase space of a dynamical system often has a high and complex dimensional space. Although a suitable pair of embedding dimension and time delay are appropriately selected when performing the reconstruction, the phase space structure may consist of a number of irrelevant and redundant variables and noises. The fact of equidistance time delayed variables in the phase space reconstruction can be one of the reasons. In this paper, the univariate and multivariate phase space dimensionality reductions based on principal component analysis (PCA) are proposed to solve these issues by creating a compact and lower dimensional phase space of a dynamical system which can improve the accuracy of chaotic model predictions. The chaotic model is built using adaptive local models based on the dynamical neighbours in the reconstructed phase space of observed time series data.

The ocean surge time series data along the Dutch coast which are characterized as deterministic chaos are used as good candidates for testing the proposed method. In practice, the chaotic model can serve as a reliable and accurate model to support decision-makers in operational ship navigation and flood forecasting.