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Nonlinear Processes in Geophysics
Discussions

Interactive comment on "Role of nonlinear interaction between water and plant in stability analysis of nonspatial plants" *by* Guodong Sun and Xiaodong Zeng

Anonymous Referee #2

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Review of "Role of nonlinear interaction between water and plant in stability analysis of nonspatial plants" by Guodong Sun, Xiaodong Zeng

Summary

In the present manuscript, the role of the nonlinear interactions between water and plant are studied in arid semi-arid regions considering a simple model involving two variables: the 'water input' and the 'plant biomass'. Three methods are considered, the (linear) Lyapunov method, the Linear Singular Vector and the nonlinear method developed by the authors. The authors conclude that only the nonlinear method developed by the authors succeeds in describing the nonlinear interactions whereas linear

methods fail.

General comments

To study the nonlinear interactions between observed variables is an important problem in Biosystems and more generally in Geosciences since nonlinear interactions can have a very important role in the dynamical behaviors observed in real world. To study the nonlinear interactions between 'water input' and 'plant biomass', the authors take a spatialized model introduced by Klausmeier in 1999 [1], as case study. For the present study, this theoretical model is simplified by disregarding the space derivatives that are set to zero. A two-variable system is obtained that involves two nonlinear terms (actually, the same nonlinear term w.nˆ2 in each equation). To investigate the role of the nonlinear interactions, the authors consider three methods. Surprisingly, two are linear and therefore, obviously not adapted to investigate the role of nonlinear interactions: methodologically, the comparison is of poor interest. Moreover, explanations about the two alternative methods (the Lyapunov method and the linear singular vector (LSV) are extremely poor and no references are provided to the reader. Note that Lyapunov exponents [2] (which are well adapted to characterize the nonlinear behaviors) may probably be more adapted to perform such a comparison?

The theoretical background of the method developed by the authors consists of rewriting the original system of ordinary differential equations with a perturbation added to each variable. The water input w thus becomes W + w', and the plant biomass n becomes N + n'. How these perturbations are used is not explained in detail in the text, it seems to be basically considered as initial perturbations (see p. 2 lines 32-33; p.4 lines 92-94). How the contribution of nonlinearity (in comparison to linearity) is performed is not clearly explained and thus poorly convincing to investigate the role of the interactions.

The choice to study a two-dimensional system is another big limitation since only quite basic dynamical behaviors can be expected in dimension two (Poincaré-Bendixson

theorem). Note that a model of much higher complexity could be obtained for crops in semi-arid regions directly from observational data [3] which shows that the periodic solutions of the two-dimensional model considered in the study is obviously oversimplified.

The signification of the two variables involved in the model are very poorly explained. This makes the link with real world (plants in arid and semi-arid regions) particularly weak.

For these multiple reasons, I cannot recommend this manuscript for publication in an international journal such as Nonlinear Processes in Geophysics.

References

[1] Klausmeier, C. A., 1999. Regular and irregular patterns in semiarid vegetation, Science, 284, 1826-1828.

[2] A. Wolf, Swift J.B., Swinney H.L., Vastano J.A., 1985. Determining Lyapunov exponents from a time series, Physica D: Nonlinear Phenomena, 16(3), 285-317.

[3] Mangiarotti S., Drapeau L., Letellier C., 2014. Two chaotic global models for cereal crops cycles observed from satellite in northern Morocco. Chaos, 24(2), 023130.

Detailed comments *p. 4, line 111, equations (1) are inconsistent (squares are missing for X and Y). Same type of problem p. 5 line 119 and p. 11 line 274.

*p. 11, lines 293-295 “It is found that the linear stable grassland and desert equilibrium states are nonlinear stable when there is enough larger variation of initial perturbation.”: The model is actually exclusively theoretical (it is not derived from observations and there is no data to validate it), and it is extremely basic, that it is difficult to have such definitive conclusions about the real world.

*p. 11, lines 296-298 “it is demonstrated that [. . .]”: you don’t have enough arguments to get such a conclusion.

*p. 11, lines 298-299 “The CNOP approach could reflect this nonlinear character, but the Lyapunov method and the LSV method fail.”: linear methods cannot handle nonlinear problems, there is fully expected, isn’t it?

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