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Earth System Dynamics
Discussions

Interactive comment on "Early warning signals of tipping points in periodically forced systems" *by* M. S. Williamson et al.

Anonymous Referee #2

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The paper addresses the topic of data-based early-warning signals for tipping points in periodically forced systems. Three methods are proposed: phase lag, amplitude amplification and increasing nonlinearity of the system's response close to the critical transition. They are exemplified in a simple conceptual model. A time series of Arctic sea ice area is then investigated as an application.

The paper discusses a relevant and interesting topic. The work extends and enriches a research stream in recent years on tipping points and their possible precursors in climate and earth system science. The paper certainly contains elements that merit publication in Earth System Dynamics. The theory is nicely linked to earth system science; examples of earth system components in the various time scale limits are given. The application to Arctic sea ice with a negative result is basically convincing;

possible restrictions (constant forcing amplitude?, bifurcation without preceding change in time scale) are discussed. However, there are issues that need to be addressed by the authors before approval for publication.

In my opinion, the main issue is that the proposed mathematical techniques are not novel (as already pointed out by Reviewer 1) although they are presented as such. It is really strange that the manuscript completely disregards previous work in the literature in this area. There is the pioneering work by Wiesenfeld (Journal of Statistical Physics, 1985). It appeared long before the subject of critical transitions became so popular in the applied sciences and the buzz word of a "tipping point" was even created. There is the recent study by Zhu, Kuske and Erneux (2014) which goes in a similar direction as the authors' work. Reviewer 1 is pointing out more previously developed techniques the present work should be linked to.

Maybe the authors should present more applications of their techniques to earth system components rather than just mentioning possible candidates.

Figure 8 just shows that the annual cycle in the Arctic sea ice area data is quite strongly aharmonic, corresponding to a nonlinear response of the system to the solar insolation forcing, as is well known and already clearly visible by eye from the time series. The evolution of the strength of the nonlinearity over time, which is actually proposed by the authors as an early-warning signal when approaching a possible bifurcation, is not considered at all.

Interactive comment on Earth Syst. Dynam. Discuss., 6, 2243, 2015.