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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.

**M. S. Williamson et al.**

m.s.williamson@exeter.ac.uk

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We thank the referee for their time and generally positive appraisal of our manuscript. Many of the concerns of referee 2 are the same as our first referee and our responses to these concerns, if not detailed enough below, can be found in our reply to Christian Kuehn. We reply below (ref #2's original text in italics followed by our response):

> *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.*

We agree that we should have referenced previous work more thoroughly and this has been rectified in a revised version of the manuscript. Please see our first response to Christian Kuehn and his point (1) and (2) for more details.

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

Please see our first response to Christian Kuehn.

> *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.*

This is a good point and we thank the referee for pointing this out. We assumed mistakenly that to reliably resolve the peaks of the harmonics in the Fourier spectra would require a large amount of data that would make a sliding window analysis of the time series difficult. It turns out for the Arctic sea-ice observations one can reliably resolve

the peaks with only 10 full cycles. We have therefore been able to plot harmonic amplitude against time using a sliding window of 10 years and have added this analysis. Like the other indicators for the sea ice, no convincing trend is seen. We have also included the same analysis for the conceptual model example showing the harmonic amplitudes increasing as the local bifurcation is approached.

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