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The Cryosphere Discussions

Interactive comment on "A recent bifurcation in Arctic sea-ice cover" *by* V. N. Livina and T. M. Lenton

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We would like to thank Peter Ditlevsen for the constructive criticism. His argument is well taken. Our key point is that there has been a jump in the amplitude of the seasonal cycle of sea-ice variability around 2007. We actually discovered this shift with our relatively complex methods, then went back to the raw maxima and minima data and plotted Fig. 1 of the paper.

The question then becomes how to interpret a jump in the amplitude of the seasonal cycle? We hypothesize the appearance (through a bifurcation) and subsequent sampling (predominantly during summer) of a new low ice cover attractor. If there is some other mechanism by which the amplitude of the seasonal cycle can suddenly jump in amplitude in a way that persists, we welcome suggestions on that. Our explanation

should be viewed as a hypothesis, but not the only conceivable one.

In revising the paper we propose to clarify the sensitivity of our results to how the data is deseasonalised. To explore the issues raised, we have conducted experiments with artificial data with a variable seasonal cycle. We built a simple stochastic model of "daily" data (period 365) with decreasing linear trend and increase of amplitude of the sine wave after 20 "years".

Analytically, the model is described by the following equation:

$$x(t) = L + A \cdot \sin\left(\frac{2\pi t}{365}\right) + \sigma\eta,$$

$$A = \begin{cases} 1, & \text{when } t = 1, \ldots, 7300, \\ \frac{0.5}{12410-7300}t + \frac{12410-1.5\cdot 7300}{12410-7300}, & \text{when } t = 7301, \ldots, 12410, sign\left(\sin\left(\frac{2\pi t}{365}\right)\right) < 0, \end{cases}$$

where η is Gaussian white noise of unit variance, $\sigma = 0.15$. Argument $t = 1 : 12410$ denotes 34 years of "daily" data, equivalent to period 1979-2012. The amplitude of the sine wave grows linearly after 20 "years" of simulated data (starting from "year" 1998), so that the amplitude of the lower half of the sine wave changes from -1 to -1.5 at the end of time series. The global declining trend of the dataset is simulated as linear in form $L = -0.02 \cdot t + 55.82$.

The deseasonalised fluctuations were further detrended and indicators calculated.

This model experiment shows a qualitatively similar set of results to the real data. We plan to include discussion about it in revising the paper. We also plan to rephrase our paper in terms of a hypothesis of bifurcation – to explain the jump in amplitude of the seasonal cycle – which is then tested with the various methods. Still, the profound change taking place in the data in 2007 and since was detected by our methods, suggesting they have some value, the question becomes how to interpret the results.