Authors' replies to Anonymous Referee #1

A. General authors' reply

As we have clarified in our paper (from the beginning, e.g. from the abstract), our main target is to investigate whether the major ENSO events provide precursory signals and our conclusion is that, in fact, the major ENSO events provide precursory SOI signals that are maximized in a time window of almost two years. These precursory signals are used to estimate whether a SOI maximum exceeding a plausible target value (based on the SOI values observed during ENSO events) is approaching thus giving an alert. This alert is either on or off (binary prediction), without affording at the current stage a certain value for the impending SOI maximum. Hence, our method differs essentially from other current statistical methods which usually provide an expected value of SOI on a monthly basis. Consequently, it is not feasible to make any direct comparison between the proposed tool and the already existed ones. Nevertheless, we shall present in the revised version an indirect comparison between the proposed method with the other forecasting models and methods taking into account the Reviewer's suggestion on point numbered 7 below.

B. Specific authors' replies

General comments:
1. This discussion paper … there is no evidence provided to support this claim.

We intend to add to the revised version of our manuscript a comparison of our method with a few of the existing ones. An extended comparison of our method with the currently used ENSO forecasting models and methods will be presented in a forthcoming paper.
Regarding the physical explanation of the mechanism for skill obtained is based on the properties of the change under time reversal of the natural time entropy which quantifies the competing mechanisms leading to the SOI value. This explanation will be included in the revised version.
Our claim that "This finding… ENSO extreme events" is based firstly on the results of ROC analysis presented in our manuscript and secondly on our suggestion that the combination of the existing forecasting models with our method, will improve the accuracy of the short-term prediction of ENSO extreme events. We shall add a brief discussion on it to the revised version of our manuscript.

Specific comments:
2. From the example … whereas for SOI they are regularly spaced.)

Both in the caption of Fig. 1 and in the text (paragraph just below Fig. 1) we make clear that Fig. 1 refers to the time series of SOI maxima (thus irregularly spaced) and not to the SOI monthly mean values (regularly-spaced).

3. The calculation of a windowed statistic … is related to the 'probability to observe it'.

In the revised version of our manuscript we indend to clarify this point along the following lines: p_k is the normalized intensity of an event, and since it is smaller than unity and all p_k sum to unity can be regarded as probabilities.

4. In Fig. 2 ΔS is shown … if a smaller subset of the timeseries was shown.

We shall clarify this point adding further discussion on Fig. 2 in the revised paper. The use of a smaller subset of the time series indicating the relation between ΔS and SOI is presented in Figures 5 and 6.

5. In section 4 the method is applied to SOI prediction … could be provided for each T considered.)

We will make this point clearer and we will insert the requested information.

6. Fig. 3 shows ROC graphs … for a simple persistence prediction scheme.)

We shall follow the recommendations in the revised version.

7. At this point … and this aspect could also easily be investigated.)

In the revised version we shall attempt such a comparison.

8. Case studies … based on results for zero month lead times.

We will insert the relevant discussion in order to make this point clearer. However, we note that in the final version of our manuscript presented in ACPD we claim prediction "in advance" instead of "well in advance" for the case studies of the major 82/83 and 97/98 El Nino episodes.

9. Information about skill … to assess the merit of the new method.

Such a comparison will be made in the revised version.

10. I did not understand … its behaviour approaching 'critical points'.

We shall explain this point in more details in the revised version.

11. An aside: I would be curious … there is no mention of this aspect.

We shall add more information on this point in the revised version.

Authors' replies to Anonymous Referee #2

A. General authors' reply

Before going through the point-by-point comments of the Referee #2, we would like to mention the following:

1) One general issue noted by Referee #2 is verbatim the following:
"*Generally, before any forecast methodology is implemented or even presented to the public in the weather or climate literature, that technique has been tested in real time for months or years and the forecast skill compared with that of currently used forecast techniques.*"

However, it is not the case, when dealing with variability at long time scales. For example, several natural phenomena (like that of El Niño in our paper), exhibit extreme events, in relatively long time scales, and thus the statistics to test a method for their forecasting in real time, requires several decades of observations. In this case, instead of waiting to collect the statistically required long dataset (for which sometimes the entire life is not enough), it is preferable to test such a forecasting tool by employing the already existed time series of observations. In the future, the open literature will make assessments about the reliability of the earlier proposed forecasting tool.

2) Another point raised by the Referee #2 is verbatim:
"*The statement that 84 months is the longest period of El Niño is just wrong*".

However, as we reported to the Introduction of our paper (first paragraph), **El Niño is an irregular phenomenon, which sometimes is described as quasi-periodic (even though there is no compelling evidence for this)**. Although Referee #2 seems to agree with this, he/she raises questions about the longest period of El Niño. However, in this regard we would like to mention just the following three points:

- The **Climate Prediction Center of NOAA** verbatim reports**: "in the historical record the period has varied between two and seven years."** (http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensocycle/soi.shtml)
- Lin (2007) analyzing observational data suggested that **ENSO displays prominent period of about 4–7 years between 1910–1965,** which is consistent with the results of many other studies (see to the point-by-point responses below).
- There is considerable modulation of the ENSO cycle and amplitude on decadal and interdecadal timescales (e.g. Linsley et al., 2000). In particular, the ENSO's period depends on its amplitude. In this regard, Eccles and Tziperman (2004) by employing a simple delayed oscillator model showed that **in the strongly nonlinear regime, the larger the amplitude of the ENSO cycle, the shorter its period**. In contrast, they found that **for the weakly nonlinear regime, the period increases with the amplitude** (see the point-by-point responses below).

3) It is non understandable that a Reviewer suggests "*In any case, the authors of this manuscript should not expect the reader of their paper to wade through earlier publications, getting bits and pieces of the methodology from each, in order to apply their method.*" because a research article should be solely focused on the original results just by citing the past literature and avoiding to repeat details already published.

B. Specific authors' replies

General comments:
1. Reviewer 1 has offered … than leaving them to others.

Several natural phenomena (like that of El Nino), exhibit extreme events, in relatively long timescales, and thus the statistics to test a method for their forecasting in real time, requires several decades of observations. It is therefore preferable, in this case, to test such a forecasting tool by employing the already existed time series of observations, despite of waiting to collect the statistically required dataset for which sometimes the entire life is not enough. The open literature will then dictate the assessment about the reliability of the forecasting tool.
As it is mentioned above in our reply to Reviewer 1, we will gladly proceed to a comparison with the existing forecasting models and methods.

2. The conceptual explanations … include more utilitarian details about the windowing.

To the best of my knowledge the book which provides the most important explanations requested by the Reviewer is available online. Therefore we thought it would be superfluous to repeat these explanations in our article which should be restricted only to the original part.

3. Despite the many shortcomings … We all live with this.

We will gladly include more references to the geophysics ENSO literature.

Specific Comments:
4. Pg. 2: El Niño is sometimes … nonlinear system with resolved nonlinearities.

We agree with the comment of the Referee and we will incorporate this discussion in our manuscript. We would like to emphasise that the concept of the entropy in natural time is "a concept equally applicable to deterministic as well as stochastic processes".

5. Pg. 4: The normalized intensity … elucidate the "intuitive" description on Pg. 9.

We shall include such a discussion in the revised version as already mentioned in our response to the Reviewer 1.

6. Pg. 5: The statement that 84 months … for windows of about two years.

We do not agree with the Reviewer's claim that "*The statement that 84 months is the longest period of El Niño is just wrong*.", for the following reasons:

- The web page for the Southern Oscillation Index of the Climate Prediction Center of the National Oceanic and Atmospheric Administration justly writes verbatim: (http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensocycle/soi.shtml) "The time series of the SOI and sea surface temperatures in the eastern equatorial Pacific indicates that the ENSO cycle has an average period of about four years,

although in the historical record the period has varied between two and seven years."

- Many observational studies have shown that ENSO is a broadband phenomenon with a wide spectral peak period. However, **there is considerable modulation of the ENSO cycle and amplitude on decadal and interdecadal timescales** (Wang, 1995; Zhang et al., 1998; Linsley et al., 2000; Newman et al., 2003; Lin, 2007). In addition, the **ENSO's period depends on its amplitude.** In this regard, Eccles and Tziperman (2004) by employing a simple delayed oscillator model showed that in the strongly nonlinear regime, the larger the amplitude of the ENSO cycle, the shorter its period. In contrast, they found that **for the weakly nonlinear regime, the period increases with the amplitude.**

- Observational analysis conducted by An and Wang (2000) revealed that the ENSO period increased from 2–4 yr during 1962–75 to 4–6 yr during 1980–93 and that it is highly dependent on the zonal phase lag between the wind stress and SST and the meridional scale of wind stress. This change in the ENSO period was found to be concurrent with the interdecadal climate shift in the North Pacific. Lin (2007) analyzing observational data suggested that ENSO displays prominent period of about 3 years before 1910, **4–7 years between 1910–1965**, 3–4 years between1965–1980, and 4–5 years after 1980. These are consistent with the results of many previous studies (e.g., Gu and Philander, 1997; Wang, 1995; Mak, 1995; Wang and Wang, 1996; Torrence and Compo, 1998).

- Kirtman (1997) performing *narrow*, *broad* and *control* simulations noticed **that despite the 5-yr period in the *control* simulation, the period was approximately 9 yr when the broader wind stress anomaly was used, while when the narrower anomaly was used the period was about 3 yr.** A potential explanation of why the broader meridional structure in the wind stress anomaly leads to longer periods could be that the higher meridional mode Rossby waves (i.e., with slower phase speeds) would imply longer delays (Schopf and Suarez, 1990). Another possible explanation could be the fact that in broadening and narrowing the structure of the wind stress anomaly, the forcing of the gravest Rossby mode changes considerably.

As far as the point that "*the authors' best results seemed to occur for windows of about two years*" we would like to clarify that the best hit rate over an almost two years period resulted independently from our analysis.

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