# Nonlinear analysis of interaction between El Niño and Atlantic equatorial mode

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Based on the nonlinear techniques for the estimation of coupling between oscillatory systems, we analyze the interaction between equatorial Pacific mode (El Niño–Southern Oscillation or ENSO) and equatorial Atlantic mode (EAM).

We use several monthly mean indices for El Niño (EN) and EAM based on the HADISST data set (Rayner et al., 2003) for sea surface temperature (SST) since 1870 till 2006: Niño3 (5S-5N, 150W-90W) and Niño3.4 (5N-5S, 170W-120W) in the Pacific and Atlantic3 (20W-0, 3S-3N) in the Atlantic (see also (Keenlyside and Latif, 2007)).

Interaction between EN and EAM was studied with the use of cross-wavelet analyses in (Mokhov et al, 2007) where it was offered to use also methods based on phase dynamics modeling and nonlinear "Granger causality".

The quantitative characteristic of the cause-and-effect relationship introduced by Granger is defined as the prediction improvement (PI) of one signal when another signal (possibly, time delayed) is taken into account in the predictive model (Granger, 1969). The results of such analysis are compared to those obtained with cross-wavelet analysis and phase dynamic analysis.

Fig.1 demonstrates the prediction improvement and statistical significance level (estimated via F-test) versus trial time delay. Both with nonlinear Granger analysis and phase dynamic analysis, the presence of EAM → ENSO influence is detected. Thus, the conclusion about the presence of the EAM → ENSO influence is inferred at significance level $p < 0.0001$ (in other words, with confident probability greater than 0.9999) for a zero time delay (accuracy of time delay estimation is not greater than 1 month). Backward influence is not detected.

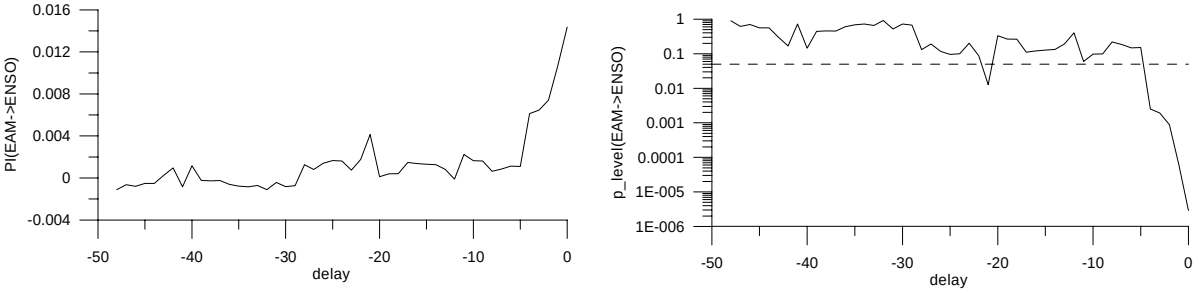


Fig.1. Estimation of the EAM → ENSO influence. Prediction improvement normalized by the ENSO variance (left panel) and statistical significance level (right panel) versus trial time delay between.

To reveal trends in coupling during the last decade, we estimate coupling between NAO and ENSO in a moving window of the length of 30 years. We started with the interval 1870–1900 and finished with 1975–2005. PI-values reveal increase in the strength of the influence EAM→ENSO (Fig.2).

Interaction between North Atlantic Oscillation (NAO) and ENSO has already been studied in (Mokhov, Smirnov, 2006). To get more complete picture of interactions between Atlantic and equatorial Pacific processes, we plan to investigate mutual dynamics of NAO and EAM in the same way.

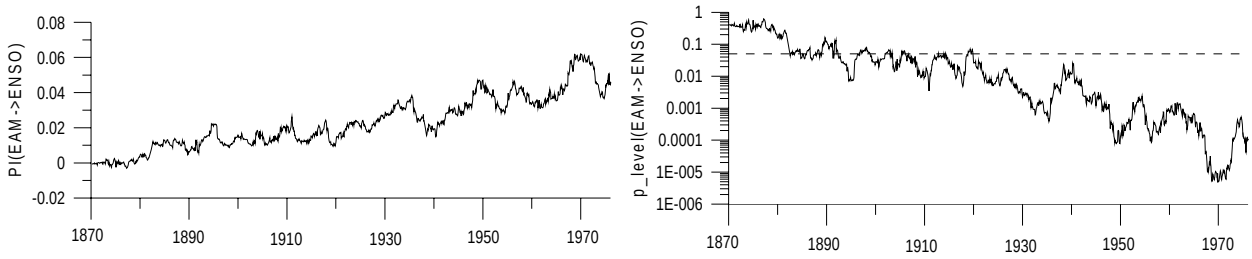

Fig.2. Influence EAM→ENSO (for zero trial time delay) in a 30-year moving window.

The work is supported by the Russian Foundation for Basic Research (grant No. 07-05-00381) and the RAS program.

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