Nonlinear analysis of interaction between El Niño and Atlantic equatorial mode based on model simulations

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Interaction between processes in the tropical latitudes of the Pacific and Atlantic oceans with the help of nonlinear Granger causality and cross-wavelet analysis is analyzed. We use monthly mean indices for El Nino-Southern Oscillation (ENSO) and equatorial Atlantic mode (EAM) based on the data set for the model ECHAM5/MPI-OM since 1900 till 2100 (for the IPCC SRES scenario A1B for the 21st century). ENSO index is a sea surface temperature (SST) for Nino3.4 (5S-5N, 170W-120W), EAM index is SST for Atlantic3 (20W-0, 3S-3N) [Keenlyside and Latif, 2007].

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 is taken into account in the predictive model [Granger, 1969]. Based on the nonlinear Granger causality analysis, statistically significant ENSO→EAM and EAM→ENSO influences without delay and with time delays of several months are detected. To assess changes in the interactions over time, the analysis in a 30-year moving window is performed (fig.1). We started with the interval 1900-1930 and finished with 2070-2100. The ENSO→EAM influence reaches its maximal value at the beginning of the twentieth century and greatly reduces over the next decade. The opposite influence at the beginning of the century is smaller, and at the end of the century is not detected. In the twenty-first century couplings in both directions are enhanced and reach maximum at the end of the century.

Cross-wavelet analysis [see Jevrejeva et al., 2003] reveals the existence of interaction between processes at different frequencies corresponding to periods from 2 to 10 years (fig.2). Interaction between the EAM and ENSO based on observational data set has already been analyzed in [Mokhov et al., 2007, Kozlenko et al., 2008]

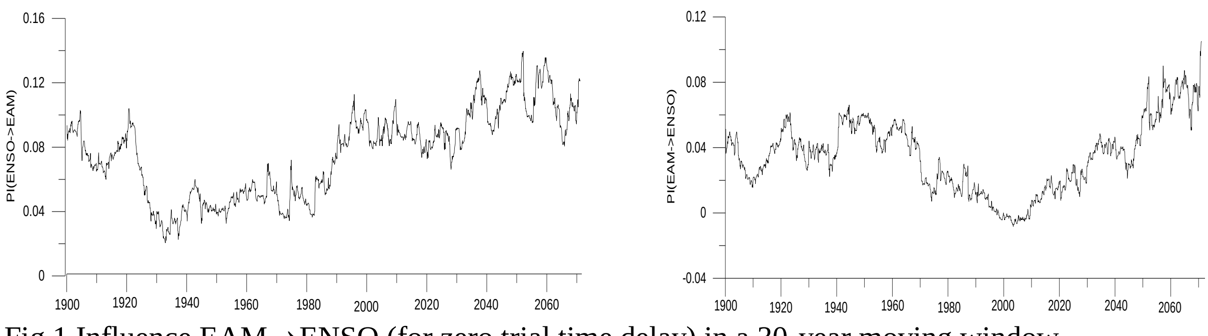

Fig.1.Influence EAM→ENSO (for zero trial time delay) in a 30-year moving window. Normalized values of prediction improvement are shown versus the start point of the moving window.

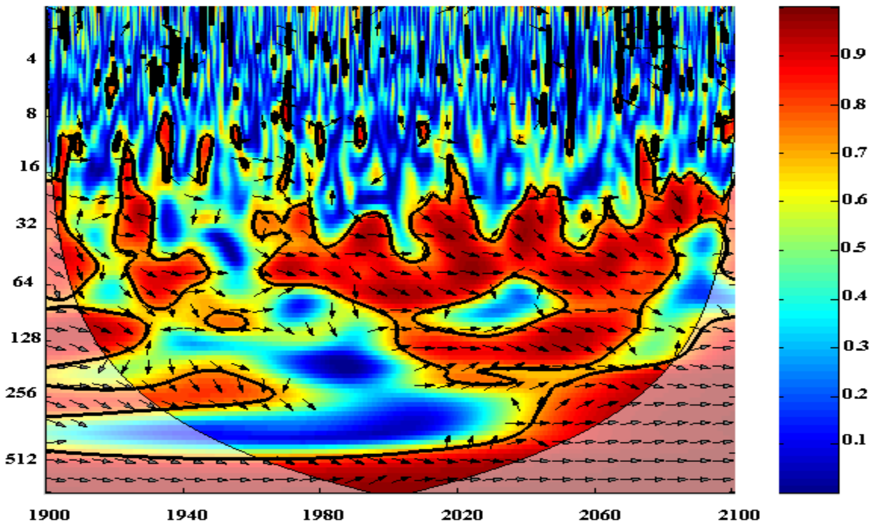

Fig.2. Cross-wavelet coherency between SSTs for Nino3.4 and Atlantic3.

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