Changes in coherence between different types of El-Nino from observations and model simulations

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The strongest interannual variations in global surface temperature are associated with El Niño processes. Different types of El Niño phenomena are manifested, including the canonical El Niño event with the largest surface temperature anomalies in the equatorial latitudes of the Eastern Pacific Ocean and the so-called El Niño Modoki with the largest surface temperature anomalies (SST) in the central Pacific Ocean in the equatorial latitudes [1]. In this work, using cross-wavelet analysis [2], we estimate the features and changes in the relationship between different El Niño indices characterizing SST anomalies in the eastern (Nino3) and central (Nino4) equatorial regions of the Pacific Ocean (see also [3,4]), using observational data (https://psl.noaa.gov/gcos_wgsp/Timeseries/) and simulations with climate models of the CMIP6 ensemble (https://esgf-node.llnl.gov/projects/cmip6/).

Figures 1(a-d) show coherence of Nino3 and Nino4 anomalies for 1870–2020 by monthly data based on observations and from simulations with historical scenario with 3 climate models (ACCESS-CM2, CanESM5 and INM-CM5-0).

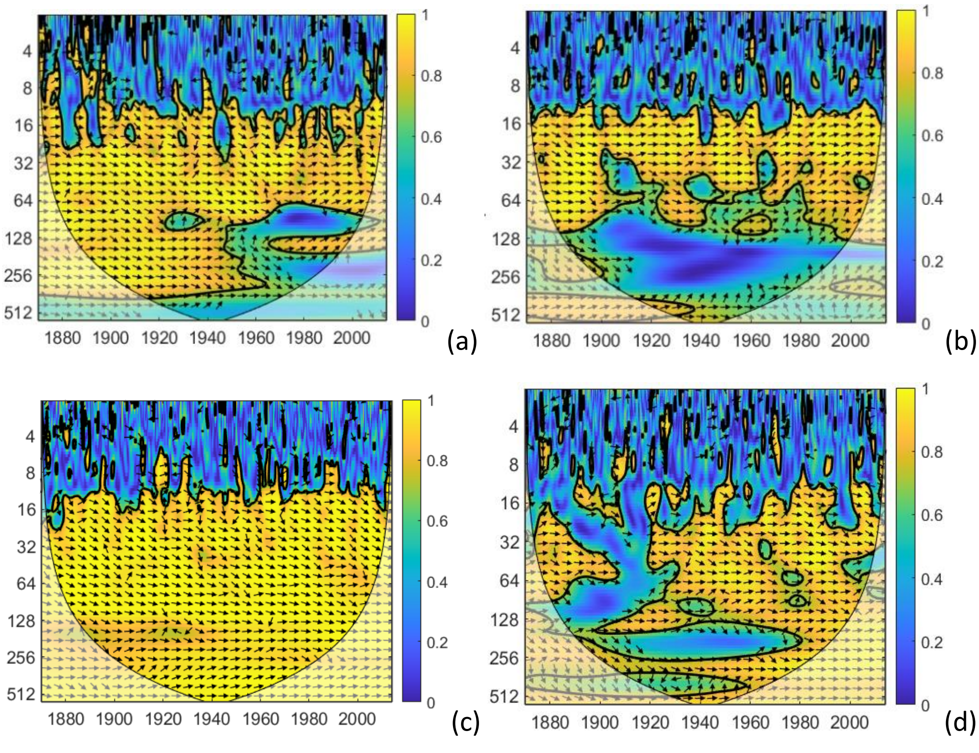

Fig. 1. Coherence of Nino3 and Nino4 anomalies for 1870–2020 by monthly data based on observations (a) and from simulations with historical scenario with 3 climate models: ACCESS-CM2 (b), CanESM5 (c) and INM-CM5-0 (d). Ordinates – periods in months, abscisses – time in years. Solid lines separate the regions of boundary effects, and bold lines limit the regions where coherence is nonzero at a significance level $p = 0.05$.

Changes in El Niño phenomena of various types according to empirical data after the middle of the 20th century differ significantly (Fig. 1a). This may not necessarily be due to real changes, but to the quality of earlier data [4]. The closest correspondence with Fig. 1a was obtained from simulations with the ACCESS-CM2 model (Fig. 1b). According to simulations with the CanESM5 model, a strong coherence of the Niño3 and Niño4 indices was obtained for all periods of more than a year for the entire analyzed time interval 1870–2020.

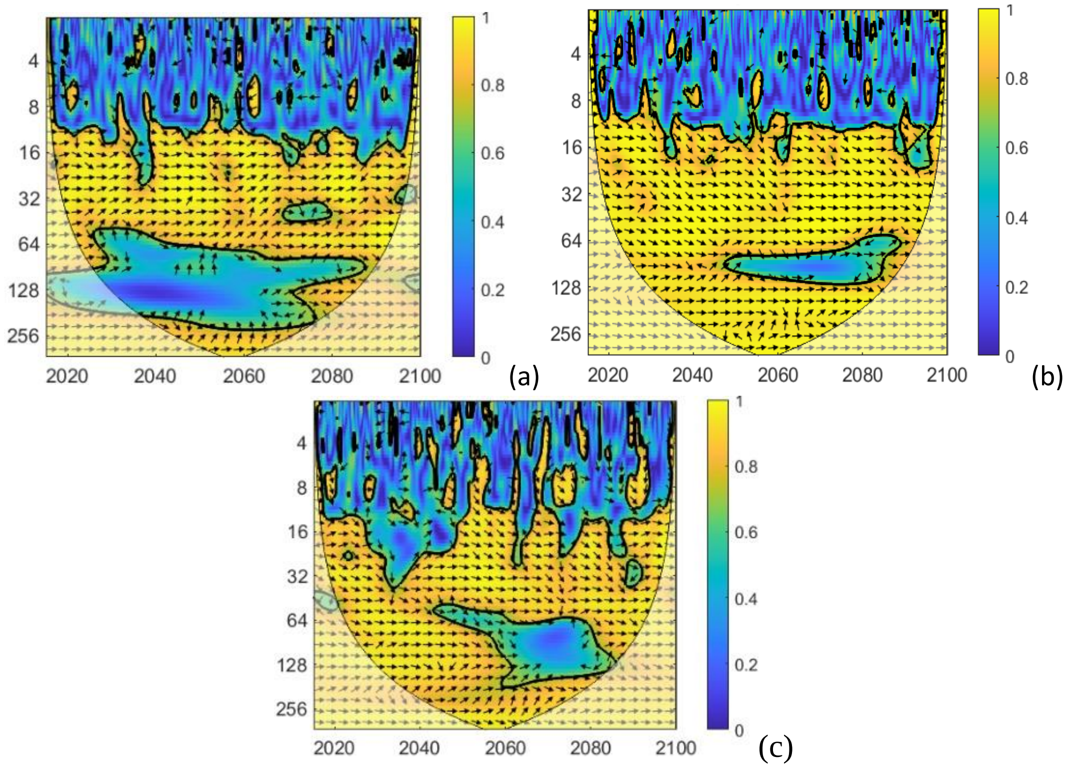

Fig. 2. Coherence of Nino3 and Nino4 anomalies from simulations for the 21st century with scenario SSP585 with 3 climate models: ACCESS-CM2 (a), CanESM5 (b) and INM-CM5-0 (c). Ordinates – periods in months, abscisses – time in years. Solid lines separate the regions of boundary effects, and bold lines limit the regions where coherence is nonzero at a significance level $p = 0.05$.

Figures 2(a-c) show coherence of Nino3 and Nino4 anomalies for 1870–2020 by monthly data from simulations for the 21st century under scenario SSP585 with climate models ACCESS-CM2, CanESM5 and INM-CM5-0. For ACCESS-CM2, with the best agreement with empirical data after 1950 (Fig.1b and Fig. 1a), with an overall high coherence of Niño3 and Niño4 for periods from one year to 5 years and more than 2 decades, their coherence does not appear for interdecadal variations until the last decade 21 century. All analyzed models show significant coherence for variations with periods about two decades and longer.

References

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