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Interactive comment on "ESD Ideas: Long-period tidal forcing in geophysics – application to ENSO, QBO, and Chandler wobble" *by* Paul R. Pukite

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Power spectra of ENSO reveal numerous spectral density peaks at the periods, which are sub- and superharmonics of three different external climate system forcings with seemingly incommensurate periods (Serykh and Sonechkin, 2019). These forces are: Chandler wobble in the Earth's pole motion ($\sim$1.2 year period), the Luni-Solar nutation of the Earth's rotation axis ($\sim$18.6 year period), and the $\sim$11.5-year Sun-spot cycle.

It is shown that the best of the CMIP5-models reproduce the ENSO spatial structure, and a nonsmooth character of its power spectra more or less well (Serykh et al., 2019). However, the periods of the modeled spectral density peaks are localized at different combinational harmonics of the annual period, but not at the afore-mentioned harmon-

ics of the three more external periodicities. Therefore, one may conclude that just the difference between peak positions in real and modeled power spectra of ENSO is the reason why the present-day forecasting models are not capable to predict El Niño with rather long lead time.

Specific characters of the ENSO autocorrelation function decreases as well as specific relationships between the spectral peak amplitudes and their serial numbers give grounds to consider the El Niño dynamics as a manifestation of the so-called strange nonchaotic attractor (SNA) well-known in the mathematical dynamical system theory (Serykh et al., 2019). This circumstance admits to believe that El Niño is predictable with no limit, in principle.

The predictability of El Niño and La Niña is investigated (Serykh and Sonechkin, 2020a). In this case, the recently discovered so-called Global Atmospheric Oscillation (GAO) is considered (Serykh et al., 2019). Assuming GAO to be the main mode of short-term climatic variability, this study defines an index that characterizes the dynamics and relationships of the extratropical components of the GAO and ENSO. Due to the general propagation of the GAO's spatial structure from west to east, another index – predictor of ENSO is defined. The cross-wavelet analysis between both of these indices and the Oceanic Niño Index (ONI) is performed. This analysis reveals a range of timescales within which the closest relationship between the GAO and ONI takes place. Using this relationship, it is possible to predict El Niño and La Niña with a lead-time of approximately 12 months (Serykh and Sonechkin, 2020a).

Using data on the distribution of temperatures in the Pacific, Indian, and Atlantic Oceans, large-scale structures of spatial and temporal variations of these temperatures are investigated (Serykh and Sonechkin, 2020b). A structure is found which is almost identical to the spatial and temporal sea surface temperature (SST) structure that is characteristic of the GAO. Variations in water temperature in a near-equatorial zone of the Pacific Ocean at depths up to about 150 meters behave themselves in the same way as variations in sea surface height and SST. At even greater depths, variations in water temperature reveal a "striped" structure, which is, however, overall similar to that of SST variations. Variations of water temperature at depths in all three oceans spread from east to west along the equator with a period of 14 months. This makes it possible to think that the dynamics of these temperatures are controlled by the so-called Pole tides. The surface North Pacific Pole Tide was found previously responsible for excitation of El Niño (Serykh and Sonechkin, 2019). The deep Pole tides in the Southern Atlantic and Southern Indian Ocean appear to be triggers of the Atlantic El Niño and Indian Ocean Dipole (IOD). Thus, IOD manifests itself at the depth of the thermocline more clearly than on the surface of the Indian Ocean. The out-of-phase behavior of El Niño and IOD is explained by the 180-degree difference in the longitudes of these phenomena.

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