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On the physical interpretation of the lead relation between Warm Water Volume and the El Niño Southern Oscillation

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The El Nino Southern Oscillation (ENSO) is the leading mode of interannual climate variability on Earth. The warm water volume (WWV), a proxy for the Pacific heat content over the entire equatorial band, is the most widely used precursor of ENSO. The standard interpretation of this lead relation in the context of the recharge oscillator theory is that anomalous easterlies during, e.g. a La Niña, favour a slow recharge of the equatorial band that will later favour a transition to El Niño. Here we show that the WWV is only the best predictor of the upcoming ENSO during boreal spring, in both observations and CMIP5 models. At longer lead times, the best predictor of ENSO is the heat content in the western Pacific (WWVw), as initially formulated in the recharge oscillator theory. Using idealised experiments with a linear continuously stratified (LCS) ocean model, we demonstrate that the WWV in spring mostly reflects the fast Kelvin wave response to wind anomalies during the early months of the year, rather than the longer term influence of winds during the previous year. It is hence not an index of the slow recharge invoked in the recharge oscillator. The WWVw evolution before spring is dominated by the forced Rossby wave response, with little contribution from reflection at boundaries. As a result, WWVw can be approximated from the integral of equatorial wind stress over the previous $\sim$10 months, hence involving a longer-term recharge than WWV. We hence recommend to use WWVw rather than WWV as an index for the slow recharge before the spring predictability barrier.