Synchronisation of the equatorial QBO by the annual cycle in tropical upwelling in a warming climate

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The response of the period of the quasi-biennial oscillation (QBO) to increases in tropical upwelling is considered using a one-dimensional model. We find that the imposition of the annual cycle in tropical upwelling creates substantial variability in the period of the QBO. The annual cycle creates synchronisation regions in the wave forcing space, within which the QBO period locks onto an integer multiple of the annual forcing period. Outside of these regions, the QBO period undergoes discrete jumps as it attempts to find a stable relationship with the oscillator forcing. The resulting set of QBO periods can be either discrete or broad-banded, depending on the intrinsic period of the QBO.

We use the same model to study the evolution of the QBO period as the strength of tropical upwelling increases as would be expected in a warmer climate. The QBO period lengthens and migrates closer towards 36 and 48 month locking regions as upwelling increases. The QBO period does not vary continuously with increased upwelling, however, but instead transitions through a series of 2- and 3-cycles before becoming locked to the annual cycle. Some evidence for the cyclical behaviour of the QBO periods in the real atmosphere is presented.