SPARC Workshop SHARP2016

Asymmetry and nonlinearity of ENSO's influence on the northern winter stratosphere

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The El Niño–Southern Oscillation (ENSO) has significant effects on the extratropical stratosphere. We are exploring the nonlinearities and the asymmetries of ENSO' influences by distinguishing the different effects of four types of ENSO, the "moderate El Niño", "strong El Niño", "moderate La Niña", and the "strong La Niña", It is revealed that the moderate El Niño and the strong La Niña are much more efficient than the strong El Niño and the moderate La Niña in modulating the northern winter stratospheric variations, thus resulting in the significant nonlinear and asymmetric characteristics in the stratospheric responses to ENSO. The tropical rainfall anomalies induced by moderate El Niños and strong La Niñas are centered over the central equatorial Pacific region near the dayline, while the convection responses to strong El Niños and moderate La Niñas are centered farther to the east. Accordingly, the anomalous Pacific–North America (PNA) wave train pattern is modulated by ENSO in a nonlinear and asymmetric way, which leads to large nonlinear and asymmetric components of the vertical E-P flux responses to ENSO. The increases of planetary waves into the extratropical stratosphere in moderate El Niño winters are thus stronger than those in strong El Niño winters, whereas the decreases of planetary waves into the extratropical stratosphere in responses to strong La Niña are stronger than those in responses to moderate La Niña. The relatively stronger/weaker E-P flux responses to moderate/strong El Niño and strong/moderate La Niña, explain the remarkable nonlinearity and asymmetry in the ENSO's effects on the stratosphere. The nonlinear and asymmetric influence of ENSO on the atmosphere is also seen in our model simulations.