Formation of Tropospheric Zonal mean Anomalies Associated with ENSO

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The zonal mean climate variability associated with El Niño-Southern Oscillation (ENSO) and its formation mechanism are investigated in relation to wave-mean flow interactions using mass-weighted isentropic zonal means determined from a reanalysis dataset. Narrowing of the Hadley circulation, strengthening of the extratropical meridional circulation, and consistent modulation of the Eliassen–Palm (EP) flux divergence are confirmed as features of the ENSO warm phase. During the ENSO warm phase, EP flux divergence and convergence are intensified in the lower and upper troposphere with enhancement of upward wave propagation in the mid-latitudes. The wave propagation anomalies are likely to be induced by enhanced baroclinicity in the subtropical lower troposphere which, in turn, contributed to enhancing the extratropical meridional circulation. Therefore, it is possible to explain the formation of the ENSO related zonal mean anomalies from the baroclinicity anomalies in the lower troposphere. In addition, wave forcing anomalies in the subtropics occur with the poleward anomalies of wave propagation in the mid-latitude upper troposphere during the ENSO warm phase. These anomalies suggest a weakening of the equatorward wave propagation of climatological mean, which contribute to the narrowing of the Hadley circulation and to the westerly wind strengthening on the equatorward flank of the subtropical jet. The anomalies of the wave activity and refractive index in the ENSO warm phase suggest a positive feedback on the zonal mean flow anomalies. We also analyzed the global energy budget fluctuation associated with ENSO. The global mean wave energy does not fluctuate with ENSO, however, the globally averaged zonal mean energies increase during the ENSO warm phase. The latitudinal distribution of energy conversion from zonal mean kinetic energy to wave energy shift to the equatorial side during the ENSO warm phase. The results show that the El Niño condition induces an equatorward shift of the latitudinal distribution of the energy conversion.

Key words: ENSO, wave-mean flow interaction, zonal mean circulation